SCOTTISH CROP RESEARCH INSTITUTE

ANNUAL REPORT 1981

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SCOTTISH CROP RESEARCH INSTITUTE

FIRST ANNUAL REPORT 1981

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Jill E. Middlefell, H.N.C.

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G. E. L. Swan
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P & GS. E — M. P. L. Campbell

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L. G. Robertson

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Helen E. Stewart, M.I.Biol.

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Experimental Worker	Mrs Elizabeth M. Wann

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Experimental Worker	Mrs Elizabeth B. Hoy

Strategic Pathology Unit

Head of Unit	Jean F. Malcolmson, B.Sc., Ph.D., M.I.Biol.
Experimental Worker	Mrs Margaret H. B. Armstrong

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Head of Division	F. J. W. England[1], B.Sc., Ph.D.

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A. Young

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[1]Officer-in-charge w.e.f. 1.1.82

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* Honorary Lecturer in the University of Dundee
\+ Honorary Lecturer in the University of St. Andrews
† Honorary Senior Lecturer in the University of St. Andrews
‡ Visiting Professorship in the University of Strathclyde
° Honorary Fellow in the University of Edinburgh

GENERAL REPORT

C. E. TAYLOR

This is the first Annual Report of the Scottish Crop Research Institute, formed by the amalgamation of the Scottish Horticultural Research Institute at Invergowrie with the Scottish Plant Breeding Station at Pentlandfield. The amalgamation was proposed by a Working Party set up by the Secretary of State for Scotland in 1978 and the recommendations were accepted in December 1979. To facilitate the amalgamation the Scottish Horticultural Research Institute was renamed in October 1980 and the Scottish Crop Research Institute began to operate as such from 1 February 1981 when the Scottish Society for Research in Plant Breeding relinquished the management of the Scottish Plant Breeding Station.

It will be several years before an extensive building programme at Invergowrie is completed and the staff at Pentlandfield can be transferred to the Institute at Invergowrie. An extension to the plant breeding glasshouse and header house was completed during the year; a new virology glasshouse with header house was started in April and is expected to be completed by July 1982. Plans have been prepared for a brassica crop handling building and for a zoology glasshouse with header house, and work on these is expected to start in 1982.

The research programme for the Institute was outlined in the report of an ARC Programme Review Group published in May 1980 to which the Secretary of State responded in October 1980. The programme is largely an integration of the scientific and crop interests of the two amalgamated institutes but with some important changes, notably the termination of the strawberry breeding programme at the West of Scotland Unit, Auchincruive, the phasing out of the horticultural brassica breeding programme, and with spring oat breeding being constrained to collaboration in the trialling of selections from the Welsh Plant Breeding Station. The resources of the Institute will be concentrated on the breeding of potatoes, forage brassicas, barleys and soft fruits with research on the agronomy, physiology and plant pathology of these crops and on others which may be of importance in northern Britain.

A new management structure has been devised to make the most effective use of staff resources in relation to the research programme and to provide the flexibility to respond to any necessary changes of direction in research, or

to new research interests, or in finance. The new management structure is still the subject of discussion with the Department of Agriculture and the Staff Lists on pages 5-12 and the organisation of this Annual Report accords with the management structures which existed at the two institutes prior to their amalgamation. However, the reports of the various departments reflect some of the changes that have taken place during the year to accommodate the revised research programme. The proposed structure provides for four science divisions (Crop Sciences, Crop Protection, Plant Breeding and Virology) supported by four service divisions (Administration, Engineering and Maintenance, Estate and Information Services). The science divisions are further sub-divided into departments to provide a line management reflecting the wide spectrum of research activities in which the Institute is now involved.

The Earl of Mansfield, Minister of State at the Scottish Office, visited Mylnefield and Pentlandfield stations of the Institute on 16 October. Among other distinguished visitors to the Institute were Dr. R. Riley, Secretary to the Agricultural Research Council, who delivered the eleventh SSRPB lecture entitled 'Research: An Agricultural Resource', Professor Sir Kenneth Mather, Dr. K. Dexter, Director General of ADAS, Professor J. A. F. Rook, ARC and Mr John Purvis, Member of the European Parliament. The Institute was also pleased to receive many other visitors from overseas and the UK.

On behalf of the Institute staff both at Mylnefield and Pentlandfield I would like to thank all the farmers and landowners, colleges and official organisations who have provided field facilities, and workers in universities and official and industrial laboratories who have provided valuable scientific assistance during the year.

The Eucarpia Cruciferae Newsletter is edited and produced by staff of SCRI. Worldwide interests in the cruciferous crops is demonstrated by the distribution of Newsletter No. 6 (1981) to 274 recipients in 27 countries. The costs of printing and mailing which continue to rise unavoidably are met by generous donations from commercial interests.

Governing Body

The Goverening Body was augmented by the appointment of Professor J. L. Jinks and Mr G. D. Morrison.

In the 1982 New Year's Honours List Her Majesty the Queen conferred the CBE on the chairman, Mr John Arbuckle.

Mr W. A. Biggar was appointed to the Consultative Board of the Joint Consultative Organisation.

Appointments

C. E. Taylor was appointed as visiting Professor in the Department of Biology, University of Strathclyde.

The following members of staff were appointed during 1981:

Margaret Armstrong.	EWII. Strategic Pathology Unit
J. R. K. Bennet	EWIII. Estate Section
Moira Brunton	ASO. Virology Section
P. D. S. Caligari	SSO. Commercial Breeding Department
S. A. Cootes	Agricultural Worker. Field Staff
H. V. Davies	SSO, Crops Research Section
Fiona J. Dunn	ASO. Commercial Breeding Department
Patricia E. Dyce	ASO. Brassica Department
Mrs Loraine Galloway	Personal Secretary. Administration
R. A. Jefferies	SO. Crops Research Section
Ann Jenkins	ASO. Virology Section
Rosemary S. Jones	ASO. Crops Research Section
Jacqueline A. L. Joyce	ASO, Strategic Breeding Department
R. Kidger	SO. Statistics and Computing
Victoria MacCrimmon	ASO. Mycology Section
Mrs Valerie Magrath	Clerical Assistant. Administration
E. W. Milne	ASO, Pathology Department
G. Reilly	Caretaker/Handyman. Building & Works Unit
Mrs Jennifer Reilly	CO, Administration
Jacqueline Ross	ASO. Mycology Section
Gillian L. Simpson	ASO. Virology Section
Mrs Audrey Sinclair	Typist, Administration
Kay Williamson	ASO. Pathology Department
W. Wood	ASO. Cereals Department

Promotions

B. D. Harrison	SPSO—DCSO
D. L. Jennings	PSO—SPSO
B. Williamson	SSO—PSO
H. Barker I. A. Cowe J. W. McNicol Cynthia J. Williamson	HSO—SSO
R. Borzucki J. Brown Heather A. Ross	SO—HSO
Jill E. Middlefell Jean Spence	ASO—SO

Awards

M. M. Anderson was awarded the Scottish Horticultural Medal by the Royal Caledonian Horticultural Society.

H. Barker	Ph.D., University of Dundee
Geraldine Cruikshank	City and Guilds of London Institute Advanced Certificate in General Photography
W. Dick	Long Service Award of the Royal Highland and Agricultural Society
D. M. Farrer	HNC
W. J. Fielding	M.Phil. Edinburgh University
Dorothy J. Gemmell	Membership of the Institute of Biology
D. H. Goodall	Award for best first year ATB student at Oatridge Agricultural College

B. S. Griffiths won the Viviane Maggi prize for the best talk given by a young histochemist at the Annual Meeting of the Histochemistry and Cytochemistry Section of the Royal Microscopical Society, 14-15 April 1981. His talk was entitled 'Plant nuclear changes induced by the nematodes *Xiphinema diversicaudatum* and *Longidorus elongatus*.'

Dawn L. Harris	HNC
W. H. Macfarlane Smith	Fellowship of the British Institute of Management
J. C. Penman	B.A. Open University
D. Ritchie	City and Guilds of London Institute Certificate in Farm Business Management
G. W. Swinney	HNC
Clare E. Thomas	HNC with Distinction, Napier College of Commerce and Technology Medal; Preece Prize of the Institute of Biology
A. C. Wilkinson	HNC
P. M. Waterhouse	Ph.D., University of Dundee

Resignations

Wendy Adams	ASO, Virology Section
Erica M. Bell	ASO, Virology Section
Mrs Janet H. Campbell	ASO, West of Scotland Unit (Auchincruive)
Mrs Norma Colliar	ASO, Mycology Section

Wilma Farrell	LA, West of Scotland Unit (Auchincruive)
G. P. Gallagher	Agricultural Worker, Agronomy Division
Mrs Lynn Hunter-Johnston	CO, Administration (Auchincruive)
Gillian E. Lightbody	CO, Administration
Fiona Mathieson	ASO, Pathology Department
D. McIntosh	CO, Administration
Teresa McNally	ASO, Mycology Section
Helen E. Playfair	CA, Administration
Mrs Myra J. G. Purves	Specialist Typist, Administration
T. P. Reid	ASO, Plant Breeding
K. N. Weaver	SO, Crops Research
A. C. Wilkinson	ASO, Cytology Unit
Dawn Williams	ASO, Virology Section
Elizabeth A. Young	ASO, Brassica Department

Retirements

Mr W. C. W. Jolly, P & GS E, Estate Section, retired on 24 May 1981 after 17 years of service.

Miss Ruby B. L. McGill retired on 8 June 1981. She was personal secretary to three of the directors of the Institute (Mylnefield), covering a period of 17 years.

Visiting Workers

Dr Maria Arias-Delgado (Instituto Espagnol de Entomologia, Madrid, Spain) arrived on 7 September to spend 2 months in Zoology Section studying the ecology and feeding behaviour of longidorid nematodes. The visit was financed by the Royal Society.

Dr A. Bello (Instituto de Edafologia, CSIC, Madrid) spent 2 months working on the application of numerical methods to biogeography and ecology of plant and parasitic nematodes.

Dr Hildburg Beier (University of Wurzburg, Germany) spent 6 weeks collaborating in research on virus replication in leaf protoplasts.

Dr Mariella Coiro (Istituto di Nematoligia Agraria applicata ai Vegetali, Bari, Italy) arrived in September to spend 6 months studying the morphology and biology of, and virus transmission by, longidorid nematodes.

Pirkko Harju (University of Helsinki, Finland) spent 4 months gaining experience in techniques for handling *Erwinia* spp.

Mr P. Mills (Northern Ireland Department of Agriculture) spent 6 months learning plant virus techniques and helping with research on tobacco rattle virus.

Dr L. Rey (Instituto Espanol de Entomologia, Madrid) spent 1 week studying potential applications of microcomputers to entomological research.

Research Students

Vivienne M. Anthony (SRC-RCCA post-graduate student, jointly with the University College of North Wales) continued research on the infection of raspberry by rust, *Phragmidium rubi-idaei*. (Mycology Section)

R. A. Bain (Edinburgh University) continued work on factors involved in resistance to potato tuber rotting diseases, especially gangrene. (Potato Division)

D. J. F. Brown continued his studies on the distribution of Longidoridae (Nematoda) in Europe and variation in the morphology and virus transmission in *Xiphinema diversicaudatum*. (Zoology Section)

Christine J. Bruno (née Whitehart) (SRC-RCCA post-graduate student, jointly with the University of Aberdeen) continued her studies on the epidemiology of raspberry cane spot, *Elsinoe veneta*. (Mycology Section)

Lucy M. Cotes continued her studies on tolerance of potato to potato cyst nematode. (Zoology Section)

Angela Cunningham (Edinburgh University/RCCA Award) continued her work on pollen, embryo and endosperm development following cross-pollination within and between *Brassica* and *Raphanus* species. (Forage Division)

Sarah Dodd (ARC post-graduate student) continued her studies on the genome nucleic acids of nepoviruses. (Virology Section)

J. G. Elphinstone (ARC post-graduate student) commenced studies on contamination of potato stocks by *Erwinia carotovora*. (Mycology Section)

W. J. Fielding (Edinburgh University/PMB) completed his research on the design of potato trials. (Potato Division)

K. Forbes (SRC-RCCA post-graduate student, jointly with the Institute of Animal Genetics, Edinburgh and the University of Edinburgh) continued his studies on the genetics of *Erwinia carotovora*. (Mycology Section)

B. S. Griffiths continued his studies on the changes induced in root-tip galls by *Longidorus elongatus* and *Xiphinema diversicaudatum*. (Zoology Section)

V. M. Lumb (PMB post-graduate student) commenced studies on the effect of climate in Scotland and Israel on the epidemiology of blackleg of potato. (Mycology Section)

R. Macdonald (DSIR, New Zealand) continued his research on factors affecting SMCO levels in kale. (Forage Division)

Jane C. M. Rose (Glasgow University/RCCA Award) worked on non-specific resistance of potato tubers to *Phytophthora infestans*. (Potato Division)

N. Ross (SRC-RCCA post-graduate student, jointly with the University of Aberdeen) commenced research on the biology of *Erwinia carotovora* in the potato phylloplane. (Mycology Section)

J. C. Sequeira (Calouste Gulbenkian Foundation research fellow) continued his work on cassava latent virus. (Virology Section)

Z. Stephan continued his studies on the biology and life cycle of *Meloidogyne ardenensis* in Scotland. (Zoology Section)

D. T. Stevenson (Edinburgh University/RCCA Award) worked on tiller development in spring barley. (Forage Division)

C. R. Tapsell (Birmingham University/RCCA Award) continued work on biometrical analyses of yield and yield components in barley. (Forage Division)

Helmy Wahdan (Horticultural Research Institute, Cairo) continued his studies on environmental effects on the growth and development of the strawberry. (Crops Research Section)

P. M. Waterhouse (ARC post-graduate student) completed his studies on aphid-transmitted carrot viruses and obtained a post with CSIRO, Canberra, Australia. (Virology Section)

Sandwich Course Students

Fiona M. Black (Napier College of Commerce and Technology) worked on apical development in barley. (Forage Division)

Joan Burry (Robert Gordon's Institute of Technology) assisted from July to September with studies on drying of field bean and pea seeds in standing crops. (Crops Research Section)

P. H. Flavelle (Lanchester Polytechnic) worked on factors affecting the resistance of potatoes to late blight and soft rot. (Potato Division)

W. P. J. van Ham and J. J. Joosten (Wageningen University, Holland) worked for 3 months on plant breeding problems in *Rubus* and *Ribes*. (Plant Breeding Section)

Eileen McCabe (Paisley College of Technology) worked on the development of screening methods for brassica powdery mildew. (Forage Division)

D. C. McCalmont (Lanchester Polytechnic) worked on factors affecting the resistance of potatoes to late blight and soft rot. (Potato Division)

S. Ng (Sheffield City Polytechnic) worked on the development of software for data capture and processing. (Service Units)

V. Rao (Genetics Department, Birmingham University) worked from 8 June-7 August on genotype by environment interactions of yield components in spring barley. (Forage Division)

G. Schaafsma (Wangeningen University) spent 6 months working on breeding problems in *Brassica*. (Plant Breeding Section)

R. Shaw (Sheffield City Polytechnic) worked for 6 months on computer mapping for the European Plant-Parasitic Nematode Survey, funded by the European Science Foundation.

(Crops Research Section and Zoology Section)

Sabbatical Leave

J. M. Duncan completed 6 months at the Institut für Obstkrankheiten, Dussenheim, Heidelberg, Federal Republic of Germany studying aspects of the biology of *Phytophthora* spp.

J. A. T. Woodford, Zoology Section, returned in April from the Food Crops Research Institute, Lembang, West Java where he had been working as the International Agricultural Development Service Entomology Specialist to the Indonesian National Vegetable Research Program.

Visits Abroad

M. J. Allison visited the Institut National Recherche Agronomique, Versailles, France from 22-26 September to attend an international symposium on seed proteins and a seed protein workshop.

J. E. Bradshaw visited France from 10-16 September to meet kale breeders and discuss their breeding programmes.

D. J. F. Brown visited the Station de Recherches sur les Nematodes, Antibes, France, from 28 September to 2 October to study nematode taxonomy and electrophoretic techniques.

A. Dale visited research centres at Corvallis, Oregon; Puyallup and Prosser, Washington; Vancouver, British Columbia and the University of Minnesota, St. Paul from 22 June to 13 July to study soft fruit breeding.

M. F. B. Dale visited a number of potato breeding and research centres in Wageningen, The Netherlands, from 3-7 August. From mid-September to mid-October he visited Greece on behalf of FAO to collect seeds of wild species of *Beta nana* for genetic conservation.

R. P. Ellis visited Universitat Hohenheim, Stuttgart, Germany from 2-3 February to discuss the Joint European Spring Barley Trials with Dr. W. Schmuetz.

J. M. S. Forrest visited the Rijksstation voor Nematologie en Entomologie, Ghent, Belgium and various institutes in Wageningen, The Netherlands to study developments in nematology and potato breeding, 3-7 August.

R. A. Fox went to Wageningen, The Netherlands, 29-30 June to attend a meeting of the Editors of Potato Research and visit the Netherlands Institute for Plant Protection (IPO) to discuss research and problems of the *Erwinia*-blackleg-soft rot complex. He attended a meeting of the Disease Assessment Committee of the European Association for Potato Research in Munich, Federal Republic of Germany on 28-29 August.

R. J. Giles was based at the Gore Station of the Department of Scientific and Industrial Research, New Zealand from January to April inclusive, to select and harvest spring barley breeding material.

B. D. Harrison paid an invited visit to the International Potato Center, Peru for 3 weeks in January-February to advise on the Center's research programme on virus diseases. In September he attended a meeting in Paris of the working party planning plant pathology research in France, at the request of the French Ministry of Research and Technology. In November he paid a consultancy visit to the Overseas Development Administration's crop virology project at the Kenya Agricultural Research Institute, Muguga.

J. H. W. Holden attended business meetings of the European Association for Potato Research at Friesing, Germany from 31 March to 2 April and at Wageningen, The Netherlands from 25-27 May. He visited Israel from 6-14 May and attended an international symposium on 'Potatoes in Hot Climates' in Herzlia and toured centres of potato research and potato cultivar trials elsewhere in the country.

Lisbeth J. Hyman and K. Forbes visited the Laboratoire de Génétique des Microorganismes, Versailles from the 6-22 May to carry out a short term project on plasmids of *E. carotovora* and to become familiar with specialised bacterial genetic techniques. The visits were supported by a NATO grant.

D. L. Jennings visited the University of Santiago and raspberry growing areas in Chile from 16 to 28 November.

G. R. Mackay visited Valencia, Spain and La Puebla, Majorca from 19-24 May to inspect and harvest potato cultivar trials.

I. H. McNaughton visited IVT and SVP Wageningen, The Netherlands from 17-21 November to discuss breeding and related sciences and to attend meetings of the Co-ordinating Committee for the EEC Programme 'The Collecting of Land Races of Cruciferous Crops in EEC Countries'.

J. W. McNicol visited Wageningen, The Netherlands from 7-9 October to attend the GENSTAT Conference.

R. J. McNicol spent 21 days in France during March and April visiting M. Jacques Marionnet, Soings-en-Sologne and the Laboratoire de Biologie Cellulaire, Institut National de la Recherche Agronomique (INRA), Versailles. The visit was funded by the Eric Gardener Memorial Trust and its objectives were to study techniques of *in vitro* tissue culture with particular reference to raspberries.

M. C. M. Pérombelon visited the Laboratoire de Génétique des Microorganismes, Station de Pathologie Végétale, Versailles, France, 6-9 May, in relation to a joint project on the genetics of *Erwinia carotovora* supported by a NATO grant, and the Volcani Research Center, Israel, 10-22 May to discuss with Dr. D. Zutra the feasibility of establishing a joint research project on blackleg of potato; the latter visit was supported by a James E. Rennie award from the Potato Marketing Board.

W. M. Robertson visited Dr. Y. Spiegel of the Nematology Division of The Volcani Centre, Bet Dagan, Israel, 2-7 September, to discuss joint work, and visited S. Himmelhoch of the Department of Membrane Research, Weizmann Institute, Rehovat, Israel to see his cryosectioning technique for nematodes.

C. E. Taylor attended three meetings as a member of Scientific Council of CNR Istituto di Nematologia Agraria Applicata ai Vegetali, Bari, Italy, on 23-25 March, 29 June-1 July and 7-8 December. During 30 September-11 October, he attended a NATO ASI Conference 'Durable resistance in Crop Plants' at Martina Franca, Italy, and the Societa' Italiana di Nematologia meeting on 9-11 December.

R. Thompson attended the 8th Triennial Conference of the European Association for Potato Research, 30 August-4 September, in Munich. Financial support was provided by SAI Ltd. and the SHRI Association.

Pauline B. Topham visited Madrid from 8-12 June to discuss with Drs. Bello and Arias, Madrid, plans for their visits to SCRI, and to see their nematode sampling methods.

D. L. Trudgill visited the Station de Recherches sur les Nématodes, Antibes, France, 17-30 May, to discuss their research programme and possible areas of collaboration.

A. B. Wills attended the meeting of the International Clubroot Working Group on 15 September at Aas, Norway.

Conferences at which papers were given.

21 January	ESCA Fruit Growing Conference, Dundee	
	H. M. Lawson	Recent developments in weed control.
21-23 January	Winter meeting of Biologische Bundesanstalt, Berlin.	
	J. M. Duncan	Some aspects of the ecology of *Phytophthora fragariae*.
3 February	ADAS Calabrese Seminar, Beverley.	
	R. Thompson	Harvest scheduling of calabrese.
5 March	Virology Group Seminar, Edinburgh.	
	I. M. Roberts	Electron microscopy in virology.

17-19 March	Conference on Crop Protection in Northern Britain, 1981, Dundee.	
	L. M. Cotes	Tolerance of early potato cultivars to potato cyst nematode and its relevance to chemical control.
	S. C. Gordon	Raspberry pests and diseases are difficult targets for commercial sprayers.
	S. C. Gordon	Synthetic pyrethroid insecticides—possible uses in raspberry.
	H. M. Lawson	Potato seedlings as weeds: a new slant on the groundkeeper problem.
	M. C. M. Pérombelon	Towards an integrated control of potato blackleg.
	B. Williamson	Prospects for control of cane blight in machine-harvested raspberries.
23-25 March	Association of Applied Biologists Electron Microscope Serology Workshop, Norwich.	
	I. M. Roberts	Electron microscope serology —the practical aspects.
9 April	Society for General Microbiology Virus Group. Cambridge.	
	M. A. Mayo	The infectivity of nepovirus RNA following treatment with proteases.
10-17 May	Symposium on Potatoes in Hot Climates, Herzlia, Israel.	
	M. C. M. Pérombelon	Effect of climatic differences on blackleg etiology and epidemiology.
		Detection of soft rot erwinias in potato tubers.
		A tetrazolium fermentation indicator medium for differentiating among soft rot *Erwinia*.

7-9 July	Society for Experimental Biology, Stirling. Mechanisms of Disease Resistance in Plants.	
	G. D. Lyon	An endogenous-elicitor-releasing enzyme from soybean.
22-29 July	Fourth International Barley Genetics Symposium, Edinburgh.	
	M. J. Allison	Rapid small scale tests for the prediction of quality factors in barley.
	R. P. Ellis (J. Brown, W. T. B. Thomas, J. S. Swanston)	Early generation selection for yield.
	R. J. Giles (R. P. Ellis, W. Watson[1])	An assessment of rapid malting quality tests: results from work on the barley collection of the Scottish Crop Research Institute.
	G. R. Russell[2] (R. P. Ellis)	Environmental control of plant development and subsequent effects on grain yield.
	C. R. Tapsell[3] (W. T. B. Thomas)	Estimating the genetic components for cross-prediction of yield and its components in barley.
27-31 July	Association of Applied Biologists/Federation of British Plant Pathologists Virology Group, Oxford.	
	B. D. Harrison	Plant virus ecology: ingredients, interactions and environmental influences (AAB Presidential Address).

[1] University of Edinburgh
[2] Edinburgh School of Agriculture
[3] University of Birmingham

	D. J. Robinson	Effects of virus infection on photo-synthesis and associated metabolic pathways
	J. C. Sequeira	Serological studies on cassava latent virus.
2-7 August	5th International Congress for Virology, Strasbourg, France.	
	H. Barker	Cross protection behaviour of raspberry ringspot virus strains in protoplasts.
	B. D. Harrison	Further properties of potato leafroll virus.
	M. A. Mayo	Defective multiplication in protoplasts inoculated with genome parts from different strains of tomato black ring virus.
	A. F. Murant	Nature of the dependence of carrot mottle virus on carrot red leaf virus for transmission by aphids.
	A. F. Murant	Association between tomato black ring virus and its satellite RNA.
	D. J. Robinson	Relationships among RNA species in particles of tobacco rattle virus.
30 Aug-4 Sept	8th Triennial Conference of the European Association for Potato Research, Munich, Federal German Republic.	
	R. A. Fox	Plenary Session Review Paper. Future Contributions of plant pathology to potato quality—the healthy plant.
	R. A. Fox (M.C.M. Pérombelon)	Survival of *Erwinia carotovora* in soil and water in Scotland.
	J. H. W. Holden	The contribution of breeding to the improvement of potato quality.

	R. J. Killick (W. J. Fielding)	The effectiveness of the generalised lattice design for potato trials.
	P. D. Waister (P. A. Gill)	Changes in tuber water relations during storage, as measured by freezing curves and thermocouple psychrometry.
	R. L. Wastie (G. R. Mackay)	Problems and prospects in progeny testing for disease and pest resistance in a commercial potato breeding programme.
2-4 September	Eucarpia, Section Biometrics in Plant Breeding, Poitiers, France.	
	J. E. Bradshaw (G. R. Mackay)	Kale population improvement and cultivar production.
7-11 September	Horticultural Education Association Autumn Conference, Lincoln.	
	D. A. Perry	The influence of seed vigour on seedling establishment.
14-16 September	Franco-British Forage Brassica Conference, Rennes, France.	
	J. E. Bradshaw	Kale breeding
	W. H. Macfarlane Smith	Forage brassicas, their breeding and the market for these crops in the UK.
15-18 September	Eucarpia, Brassica, 1981 Conference, Aas, Norway.	
	S. Gowers	'Pair-cross' hybrids—a possible method for variety production.
	A. B. Wills	Allozyme frequencies and the assesment of genetic diversity in *Brassica campestris*.

25-26 September	ARS Brassica Breeders' Conference, Cambridge.	
	J. E. Bradshaw	Report on the Franco-British Forage Brassica Conference.
	S. Gowers	Report on the Eucarpia Cruciferae Conference.
	Isabel K. Munro	Consequences of volunteer oilseed rape plants on seed production of other Brassicas.
15 October	6th Public Health Laboratory Service Meeting, Porton.	
	I. M. Roberts	Immunoelectron microscopy: a rapid and effective diagnostic technique for viruses.
19-22 October	EEC Protein Group Seminar on Peas and Lupins, Sorrento, Italy	
	R. Thompson	Canopy performance in contrasting genotypes of peas.
17-18 November	'La Frambuesa', University of Santiago, Chile.	
	D. L. Jennings	Choice of raspberry varieties.
	D. L. Jennings	Raspberry management practices in Europe.
18 November	British Crop Protection Conference—Pests and Diseases, Brighton.	
	B. D. Harrison	Two sensitive serological methods for detecting plant viruses in vectors and their suitability for epidemiological studies.
23 November	ARS Computer Users' Group.	
	J. W. McNicol	Data capture at SCRI (Pentlandfield).
10 December	ADAS Calabrese Seminar, Beverley.	
	R. Thompson	The effects of spacing on head size and yield.

15-17 December	British Society for Plant Pathology Inaugural Meeting of Plant Disease and Changing Crop Practices, London.	
	B. Williamson	Mechanisation of raspberry culture and its implications for cane blight and other diseases.

Conferences organised

R. A. Fox, H. M. Lawson and R. L. Wastie served on Management Committee for Conference on Crop Protection in Northern Britain, which was held at Dundee University, 17-19 March.

B. D. Harrison, M. Mayo and A. F. Murant served as Workshop Chairman or Co-Chairman, of the Fifth International Congress of Virology in August at Strasbourg, France. Harrison was also a Vice-Chairman of the Programme Committee. Barker and Harrison received travel grants from DAFS.

R. N. H. Whitehouse, with an Executive Committee consisting largely of members of staff (M. J. Allison, M. J. C. Asher, R. P. Ellis, R. J. Giles, A. M. Hayter, J. S. Swanston and W. T. B. Thomas), organised the Fourth International Barley Genetics Symposium which was held in Edinburgh from 22-29 July.

Courses organised

J. H. W. Holden gave a course of lectures on plant breeding to botany students at Edinburgh University.

I. M. Roberts was one of three organisers of the AAB/ARS Electron Microscope Serology Workshop held at the John Innes Institute, Norwich on 23-25 March. Twenty-seven delegates from several European countries took part.

Pauline B. Topham arranged a one-day meeting of the SARI/SAC Microclub, 3 March, which included six demonstrations of microcomputer applications, and a discussion on statistical programming for micros.

D. L. Trudgill in association with ESCA organised three 1 day courses in crop inspection for potato cyst nematode in August.

A 3-week course on crop physiology, weeds, fungal pathogens and plant viruses was given at Dundee University, with thirteen members of staff acting as lecturers.

Nine members of staff gave a course on plant breeding to botany students at St. Andrews University during March.

Students from St. Andrews University received a series of thirteen lectures, together with demonstrations, on plant viruses, fungal pathogens and crop pests, with the Director and the staff of Mycology, Virology and Zoology Sections providing the instruction.

Courses Attended

T. J. W. Alphey, B. Boag and D. J. F. Brown attended the SA/AAB Workshop 'Concepts in Nematode Systematics' held at Cambridge University, 2-4 September.

J. Brown, M. J. De, Maine, D. J. Hall and Dawn L. Harris attended a forklift drivers safety course organised by the Royal Society for the Prevention of Accidents on 1 September.

I. A. Cowe and D. C. Cuthbertson attended an ERCC FORTRAN programming course from 3-6 and 11-13 August at ERCC, Edinburgh.

A. Dale attended the ARC/SERC Middle Management Course 2 held at Bristol Polytechnic from 7 to 11 September and 9 to 13 November.

G. H. Duncan and Ruth M. Solomon attended the AAB/ARS Electron Microscope Serology Workshop in Norwich, 23-25 March. G. H. Duncan also attended the Royal Microscopical Society Diploma Candidates Workshop in York, 17 September, followed by the Specialised Course in Practical Scanning Electron Microscopy in Cambridge, 21-25 September.

R. P. Ellis, A. M. Hayter, J. C. Penman and W. T. B. Thomas attended an ERCC PASCAL programming course from 25-29 May at ERCC, Edinburgh.

R. A. Fox attended an ARC Senior Management Information Course., London, 7-9 October.

P. A. Gill attended a Data Management seminar at ERCC, Edinburgh, 6 February.

R. Kidger attended an Introduction to EMAS Course from 1-5 June at ERCC, Edinburgh.

R. Kidger and J. W. McNicol attended a course on microcomputer applications from 22-25 June at ERCC, Edinburgh.

Christine Mackay attended a course on capillary gas chromatography from 21-25 September at Lanchester Polytechnic, Coventry.

D. K. L. MacKerron took part in a Data Management seminar at ERCC, Edinburgh, 28-29 October.

W. M. Robertson attended a course on Photomicrography at Brunel University, 20-24 July.

Pauline B. Topham attended an Advanced Genstat course arranged by the Program Library Unit, Edinburgh, 26-27 October.

Editorial Duties

M. J. C. Asher	Assistant Editor of *Federation of British Plant Pathologists News.*
P. D. S. Caligari	Member of Editorial Board of *Heredity.*
R. A. Fox	Member of the Editorial Board of *Potato Research.*
B. D. Harrison	Editor of *Commonwealth Mycological Institute/ Association of Applied Biologists Descriptions of Plant Viruses.* Member of Editorial Board of *Journal of General Virology.* Member of Editorial Board of *Intervirology.*
A. T. Jones	Member of Editorial Board of *Annals of Applied Biology.*
H. M. Lawson	Member of Editorial Board of *Annals of Applied Biology.*
I. H. McNaughton	Joint Editor of *Eucarpia Cruciferae Newsletter.*
A. F. Murant	Editor of *Commonwealth Mycological Institute/ Association of Applied Biologists Descriptions of Plant Viruses.*
D. J. Robinson	Member of Editorial Board of *Journal of Virological Methods.*
C. E. Taylor	Joint Editor of *Nematologia Mediterranea.* Associate Editor of *Journal of Horticultural Science.* Member of the Board of Editors of *Horticultural Research.*
Pauline B. Topham	Editor of *Horticultural Research.* Assistant Editor of *Lichenologist.*
D. L. Trudgill	Consulting Editor of *Plant and Soil.*
P. D. Waister	Associate Editor of *Journal of Horticultural Science.*
A. B. Wills	Member of Editorial Board of *Horticultural Research.* Joint Editor *Eucarpia Cruciferae Newsletter.*

Service on Committees

T. J. W. Alphey	UK representative on the European Plant Parasitic Nematode Survey.
M. J. C. Asher	FBPP Committee.
B. Boag	Nematology representative on the European Invertebrate Survey Committee. Scottish representative on the ADAS Migratory Nematode Working Party.

D. J. F. Brown	Secretary and Treasurer of the European Society of Nematologists.
M. R. Cormack	NFT Scottish Soft Fruit Panel.
A. Dale	NFT Scottish Soft Fruit Panel.
R. P. Ellis	BAPB Cereal Crop Group Committee Cereal Variety Recommended List Committee of the Council of Scottish Agricultural Colleges.
F. J. W. England	BAPB Cereal Trials Co-ordinating Committee. AAB Plant Breeding Group Committee.
J. M. S. Forrest	AAB Nematology Group Committee.
R. A. Fox	Council Member, EAPR Vice Chairman, Pathology Section, EAPR. Vice Chairman, Disease Assessment Group, EAPR. Member (Administration) Symposium Committee Crop Protection in Northern Britain, 1981.
B. D. Harrison	AAB, President. International Congress of Virology, Joint Vice-Chairman of Programme Committee. Institute of Virology, Oxford, Advisory Committee.
J. H. W. Holden	EAPR, Chairman Breeding and Varietal Assessment Section. BAPB Potato Crop Group Committee.
D. L. Jennings	NFT Raspberry Panel. NFT Scottish Soft Fruit Panel. SNSA Adviser to Committee.
R. J. Killick	AAB Plant Breeding Group Committee.
H. M. Lawson	ISHS Working Group on Weed Control in Vegetables.
W. H. Macfarlane Smith	Co-ordinating Committee of the EEC Programme on 'The Collecting of Land Races of Cruciferous Crops in EEC Countries'. Field Experimentation, Variety Development and Multiplication Panel of the National Proficiency Test Council.
D. K. L. MacKerron	Edinburgh User Friendly Database Management System Working Party.

Jean F. Malcolmson	Member of Sub-Committee E (infra-specific), International Mycological Association.
	Scottish Joint Committee for National Certificates and Diplomas in Biology.
M. A. Mayo	Society for General Microbiology, Virus Group Committee.
I. H. McNaughton	Co-ordinating Committee of the EEC Programme on 'The Collecting of Land Races of Cruciferous Crops in EEC Countries'.
J. W. McNicol	Research Council Users' Committee of ERCC.
R. J. McNicol	NFT Scottish Soft Fruit Panel.
	NFT Strawberry Panel.
W. P. Mowat	Scottish Bulb Technical Committee, Convener.
A. F. Murant	International Society for Horticultural Science, Chairman of Working Group on Small Fruit Viruses.
	International Committee on Taxonomy of Viruses, Member of Executive Committee and Plant Virus Sub-Committee.
	AAB, Convenor of Virology Group.
M. C. M. Pérombelon	Member of the Bacteriology Section Committee of the ISPP.
D. A. Perry	Chairman, Vigour Test Committee, International Seed Testing Association.
W. M. Robertson	AAB — member of Nematology Group Committee.
C. E. Taylor	ARC Research and Policy Advisory Committee.
	West of Scotland Agricultural College Glasshouse Technical Committee.
	Journal of Horticultural Science Publications Committee.
	PMB — Member of Research and Development Committee.
	President, European Society of Nematologists Board of Management.
	ACAS Scientific Advisory Committee.
	Chairman, European Plant Parasitic Nematode Survey (European Science Foundation).
	NFT (Brogdale) Advisory Committee.
Pauline B. Topham	ERCC Research Council Users' Group.
P. D. Waister	Tayside and Fife Branch Committee of the BA.
	HEA Scottish Branch Committee.
	NFT Scottish Soft Fruit Panel.
	Dundee University Botanic Garden Committee.

R. L. Wastie	Organising Committee for Symposium on Crop Protection in Northern Britain.
R. N. H. Whitehouse	General Organising Committee for International Barley Genetics Symposia.
A. B. Wills	BAPB Vegetable Crop Group.
J. A. T. Woodford	AAB — member of Entomology Group Committee.

Exhibitions and Poster Sessions

24-26 February	*British Growers Look Ahead Exhibition and Conference, Harrogate:* 'New black currants for the 80's.
3 March	*SARI/SAC Microclub meeting, Edinburgh:* Automatic weight and length data capture, and general purpose trace digitising on the Tektronix.
17-19 March	*Conference on Crop Protection in Northern Britain, Dundee:* 'Cavity spot in carrots'. 'Control of powdery mildew on swedes in S.E. Scotland'. 'Sterilisation of soils by liquid fumigants'.
7-8 April	*Workshop on Combined Break Crops, Writtle Agricultural College (organised through the Perry Foundation):* 'Combinable break crops — harvesting problems'.
22-29 July	*Fourth International Barley Genetics Symposium, Edinburgh* An opportunistic breeding scheme. A rapid method of counting spores of barley foliar pathogens using infra red reflectance. Collaborative spring barley trials in Europe. Data handling in a plant breeding programme. Selection for partial resistance to powdery mildew. The effect of population size on the efficiency of breeding method based on di-haploidy and single seed descent. The use of nutrient film techniques for single seed descent generations and selections for plant height.
25-27 August	*Ayr Flower Show:* exhibition on potato breeding featuring cv. Pentland Javelin.
1-3 September	*Farmgrow 1981, Ely:* 'Calabrese'.

2-4 September	*SA/AAB meeting 'Concepts in Nematode Systematics', Cambridge University:* 'Computer assisted identification of nematodes'. 'Computer mapping and the European Plant Parasitic Nematode Survey'.
22-24 September	*BMS/FBPP meeting 'Advances in Research on Rusts', Nottingham:* 'A rapid method of counting spores using infra-red reflectance'.
2-3 December	*Scottish Agricultural Winter Fair, Ingliston:* Exhibition on potato breeding featuring cultivars Provost, Baillie and Sheriff.

Radio and Television

C. E. Taylor, 2 February, 'The SCRI' (BBC Radio).
C. E. Taylor, 9 February, 'The SCRI' (Grampian TV).
C. E. Taylor, 10 February, 'New soft fruits' (BBC Radio).
D. L. Trudgill and P. D. Waister, 24 February, 'Potato and raspberry research at the SCRI' (Radio Tay).

INDEX TO PROJECTS

Crops Research

Plant Breeding

RESEARCH REPORT
MYLNEFIELD

CROPS RESEARCH

P. D. WAISTER

Research on the potato crop has been considerably expanded, both by the redeployment of staff as reported last year, and by two new appointments. As an aid to research planning and co-ordination of the activities at crop and plant level, a simple model of growth has been devised. Soil temperature data are used to predict emergence date, air temperature to predict date of canopy closure, and radiation interception to calculate total dry matter fixation; total yield of tuber dry matter is estimated as a fraction of total dry matter. Water and mineral nutrients are assumed to be non-limiting. This year's experiments have provided some interesting data on the range of values that might be used as inputs to the model. In particular there appears to be significant variation between cultivars in the ratio between intercepted radiation and dry matter accumulation.

Harvesting is by far the most costly operation in production of the raspberry crop. Though the supply of hand pickers is currently adequate for the Scottish crop, the position can change rapidly. Work on mechanical harvesting has therefore continued, and the activities of the past two years have produced a much better definition of sources of yield loss. Biennial cropping looks increasingly attractive, both to avoid machine damage to young cane and to improve the efficiency of catching of the fruit. Also there are encouraging indications of differences between cultivars in the ease with which ripe fruit can be removed without the green fruit. This problem of discrimination is the most intractable in terms of machine design.

CROP ENVIRONMENT

01001 *Effects of weather conditions on growth, yield and quality of soft fruit crops*

Root environment of strawberries

This experiment examined the effect of raising soil temperature on the growth and yield of strawberry cv. Cambridge Favourite. Six treatments separated the effects of ridging, mulching with polythene, soil sterilisation and soil water content.

In this second cropping year, the clear polythene treatment yielded 18.9 t/ha which was 14% more than the control treatment on flat unmulched soil.

Yield was lowest where plants were grown on an unmulched unsterilised ridge.

In late spring the soil in the clear polythene treatments dried more rapidly than in the other treatments but irrigation was not necessary until mid-June and again in early and mid-July. Soil moisture did not limit yield, as there was no response to trickle irrigation under the mulch. Roots were washed from undisturbed soil cores and root densities were calculated. There were no differences between treatments and the overall mean was 7 cm/cm^3 of soil.

(D. K. L. MacKerron, P. A. Gill, P. D. Waister)

01049 *Effects of weather conditions on growth, yield and quality of vegetable crops*

Light interception and growth of potato

Three cultivars of differing canopy type and maturity class were grown, Maris Piper, Pentland Dell and Guardian. A period of drought developed in mid to late summer and the crop became water stressed because irrigation was not available.

Harvests were made at weekly or fortnightly intervals throughout the growing season and growth increments were compared with measured values for intercepted radiation. The results showed considerable week to week variation in the relationship even in the early part of the season, suggesting that factors other than solar radiation were limiting growth. When considered over the season as a whole, however, the growth of each cultivar was adequately described by linear regressions on intercepted radiation.

The average growth rate for Guardian to 30 July was 1.84 g per MJ; for Pentland Dell to 11 August it was 1.67 g per MJ and for Maris Piper to 24 August, 1.43 g per MJ. These growth rates were attained before the onset of water stress and suggest that there is significant genetic variation between potato cultivars in efficiency of use of solar radiation. Of particular note is the figure for Guardian which is appreciably above the value of 1.5 g previously reported for a number of other cultivars. Tuber yields for the three cultivars were 53.3, 48.3 and 43.6 t/ha respectively.

(D. K. L. MacKerron, P. D. Waister)

As part of a co-ordinated set of experiments, the relationship was examined between solar radiation intercepted by the canopy and yield, for a range of cultural treatments. The treatments which were selected to give wide variation in tuber yield and provide information on which to base more detailed studies, included fertility, cultivar, spacing, planting date, and

storage temperature of the seed tubers. Irrigation was not available and water stress resulted in reduced growth and premature senescence. Senescence however did not occur at the same time for all treatments relative to the onset of drought. Under these conditions efficiency of light utilisation ranged from 1.24 g per MJ to 1.73 g per MJ. The experiment will be repeated, but with irrigation.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Changes in water status of stored potato tubers

Tubers of cv. Pentland Crown were stored at 2°C or 16°C from 9 October, 1980 to 5 March, 1981, and their freezing points and solute potentials were measured at weekly intervals (Ann. Rep 1980 p.41). Freeze dried samples from heel, mid, and rose ends of the tubers have since been chemically analysed at the Macaulay Institute for Soil Research. There were negative gradients of mono-and disacchardies from heel to rose end, and positive gradients of potassium and organic acids. These solutes are the major contributors to solute potentials in the tuber and, when the concentrations were converted to equivalent potentials, the negative and positive gradients gave almost complete balance so that there was no net gradient of solute potential along the tuber. This was true of both the 2 and 16°C tubers though the level of solute potential in the latter was appreciably higher (i.e. less negative), the difference being explicable by the difference in concentration of soluble sugars.

(P. A. Gill, P. D. Waister, W. M. Crooke[1])

Weather limitations on spray application

Cane vigour control in raspberry plantations is achieved by applying dinoseb-in-oil to remove the first flush of young canes when 10-20 cm tall in April-May. Records over a seven year period from a plantation of cv. Glen Clova at SCRI showed that on average young canes were within that range for a period of eight days. The potential spray application period is therefore very short. Crop data were combined with meteorological records to calculate the span of dates within which this 8-day period might fall. Weather records for that interval were then examined using a range of wind, rain and temperature limitations to determine the occurrence and frequency of suitable spraying conditions.

The results of the study showed that the frequency of suitable conditions was distributed in a regular manner which could be described by a theoretical distribution. This showed that in many years the time available for spraying will be severely curtailed by weather, particularly by wind. In a

[1] Macaulay Institute for Soil Research.

typical season there may be only three half-day spells within the 8-day period when conditions are 'good' for spray application and up to nine half-day periods when conditions would be classed as 'not suitable.' This emphasises the importance of adequate preparation for and timeliness in spray application for the control of cane vigour.

(D. K. L. MacKerron, H. M. Lawson)

Seasonal changes in growth of potato stem cuttings

In 1980, growth and net assimilation rates of stem cuttings of cv. Pentland Crown were monitored in successive batches placed outdoors at 2- week intervals. The same technique was used in 1981 to compare rates in Pentland Crown and the early cultivar, Maris Bard, which is reported to show very rapid canopy establishment. Late frosts at the end of April and beginning of May destroyed two batches of cuttings and thereby decreased the information available on the effects of interaction between low temperatures and relatively high radiation levels.

In the remaining 12 periods, between 1 April and 14 October, the relative growth rates (RGR), leaf relative growth rates, and net assimilation rates (NAR) did not differ between the two cultivars. This suggests that any advantage in rate of growth of Maris Bard from seed tubers is a property of the tuber rather than an inherent property of the shoot.

As in the previous season, the RGR and NAR were higher in the first half of the season than in the second half, at comparable temperature levels, probably reflecting the earlier decline of radiation than that of temperature after mid-summer.

(Heather A. Ross, P. D. Waister)

WEED INVESTIGATIONS

01021-01024 *Weed ecology and control in soft fruit, flower bulbs and vegetables*

Herbicide evaluation

Further investigations with pendimethalin, trietazine/simazine and propachlor/chlorthal dimethyl in an established plantation of cv. Malling Jewel confirmed that the margin of crop tolerance to applications made prior to cane emergence should be adequate. Fruit from treated plots is being evaluated for residues and taint. Experiments on newly-planted crops at three locations also showed no adverse effects of these herbicides. At one site a cyanazine/atrazine mixture applied at twice the recommended dose reduced cane numbers, but this treatment caused no injury at the other two sites.

In 1981, applications to swede at the 4-5 leaf stage of alloxydim sodium, NP55 or fluazifop butyl, at twice the rates recommended for control of perennial grass weeds, had no adverse effect on growth or yield. In calabrese treated similarly there were no yield reductions, but NP55 and particularly fluazifop butyl caused leaf malformation and the latter chemical delayed mean harvest date; alloxydim sodium had no effect on any aspect of growth or yield. 3,6-dichloropicolinic acid applied at twice the recommended rate as a post-emergence herbicide in swede turnip (4-5 true leaves) reduced final yield by over 20% when rain immediately followed spray application. Treatment on the following day, with no rain for at least 12 h after spraying, produced no significant loss in yield. This suggests that the crop is more sensitive to uptake of the herbicide via the roots than through the foliage.

Of a series of residual herbicides tested for control of annual weeds in swede, BAS 47902H again appeared to be at least as safe as propachlor when applied pre-emergence; a propachlor/cyanazine mixture caused severe crop injury. Incorporation of tebutam pre-sowing had no significant adverse effect on the crop at twice the recommended rate, but WL 82830 impaired emergence and slightly reduced yield.

The above experiments were designed principally for the assessment of crop tolerance. Further work with the more promising herbicides will be carried out in co-operation with official and commercial development agencies with a view to formulating label recommendations suited to Scottish conditions.

3,6-dichloropicolinic acid made up in gel formulation was applied to established dandelions *(Taraxacum officinale)* using a plastic oilcan delivering approximately 1 ml gel per crown. Application in September or April at concentrations of between 5 and 10 g a.i./l completely eradicated treated plants. Spring treatment of coltsfoot *(Tussilago farfara)* at 1 ml gel per growing point was also highly effective.

(H. M. Lawson, J. S. Wiseman)

01029 *Weed control in crop rotations*

Volunteer crops

Estimates of true seed production by a range of potato cultivars, given uniform husbandry, were taken from 44 plant units just before tuber harvest. Seeds were extracted and counted from 10 berries per cultivar. The potential return of seed to the soil for the most prolific cultivars is given below.

Cultivar	Berries/plant	Seeds (millions/ha)
Pentland Ivory	4.9	69
Bonte Desiree	6.3	67
Dr McIntosh	2.9	44
Pentland Dell	3.7	42
Cara	2.1	28
Pentland Squire	1.7	26

1981 was a relatively poor year at SCRI for fruit set in Maris Piper; berry counts at tuber harvest ranged from 0 to 6.7 per plant over 11 sampling sites across the farm. However, one crop of Desiree averaged 14 berries per plant, giving a potential return to the soil of 144 million seeds/ha.

An experiment to control potato seedlings with post-emergence herbicides applied at rates appropriate to a range of field vegetable crops produced large variations in response. Reductions in tuber production (by weight) in excess of 90% were achieved with cyanazine, metoxuron, methazole and ioxynil. No useful control was obtained with pentanochlor, desmetryne, sodium monochloracetate, ethofumesate, 3,6-dichloropicolinic acid or phenmedipham. These results suggest that choice of post-emergence herbicide in crops following potatoes can play a part in reducing the potential contribution by potato seedlings to volunteer tuber populations.

In spring, an experiment examined the ability of soil-applied residual herbicides to control volunteer populations of field bean, barley, oilseed rape, Italian ryegrass and white clover.

Moist soil conditions after application resulted in greater herbicide activity than occurred in a similar experiment in 1980. Field bean was unaffected by any herbicide and only diuron checked growth of spring barley. Bromacil, diuron and linuron reduced emergence of oilseed rape, and simazine and chlorthal dimethyl also affected the final yield. Yield reduction in Italian ryegrass with bromacil, diuron and propachlor was due mainly to effects on crop emergence. All the herbicides mentioned above reduced or prevented emergence of white clover, while ethofumesate severely stunted subsequent growth. Other than white clover, no herbicide achieved an acceptable level of control. However, linuron was sufficiently effective on oilseed rape to merit further attention in view of the wide range of field crops in which this herbicide is used. Control of the other volunteer crops in non-cereal parts of the rotation may have to be achieved by supplementary herbicide treatment or by soil cultivation.

A range of post-emergence herbicide recommendations for carrots was evaluated for control of barley, field bean and oilseed rape (all 10-15 cm tall). Linuron virtually eliminated oilseed rape, while chlorbromuron and metoxuron reduced fresh weight by 75%. All these herbicides, together with prometryne, reduced weight of field bean by 80-90%, but none achieved an acceptable level of control of spring barley.

(H. M. Lawson, J. S. Wiseman)

VEGETABLE AND ARABLE CROPS

01030 *Control of growth, yield and quality of vegetable crops by cultural methods and choice of genotype*

Potato — shoot development

Tuber size grade distributions depend in part on stem population density. Various factors are known to affect the number of sprouts that develop from a tuber to form aerial shoots. A number of such factors were examined including several types of sprout treatments which comprised: removal of all shoots, removal of shoot tips, removal of apical shoot and removal of half of the number of shoots. Tubers with undamaged shoots were planted as controls.

As averages over treatments, shoot numbers declined from about 10 shoots per plant just after planting, to six shoots per plant on 22 June, after which numbers remained unchanged to the final harvest on 15 October. Throughout the growing period there were about 25% more shoots in the shoot tip removal treatment than for any of the other treatments, all of which had similar values with an average of 5.7 stems per plant. Despite the higher stem number for the treatment with the shoot tips removed, this did not result in differences in either total yield or seed yield.

Removal of all sprouts delayed emergence by about seven days compared with that for the control and resulted in a reduction of total yield (35 t/ha) compared with that for the remaining treatments which averaged 40 t/ha.

Although stem numbers remained virtually unchanged between mid-June and mid-October, there was a marked reduction from 3.8 to 2.4 tubers per stem during this period.

A major objective clearly is to establish reasons for the decline in both stem and tuber numbers that occurred with time from the early high values recorded.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Potatoes — measured maximum (MM) yield

Comparisons were made of yields from crops grown in maximum yield conditions, or in normal soil with or without irrigation and additional nutrients. Total tuber yields at the end of October were 48 t/ha for the

non-irrigated soil plot, and an average of 103 t/ha for the irrigated soil plot and the MM plots which did not differ significantly. Tuber dry matter contents were 17, 20 and 25% for the MM, irrigated soil and non-irrigated plots respectively.

The proportion of total plant dry weight accounted for by the tubers also varied, with values of 77, 83 and 84% for the MM plot, irrigated and non-irrigated soil respectively. Tuber size distribution was markedly affected by treatment because, although the yield of tubers was similar from the MM and irrigated soil plots, there were large differences in tuber number with 204 and 126 tubers/m^2 respectively. The non-irrigated plot produced a similar number to that of the irrigated soil treatment with 113 tubers/m^2.

Such differences between treatments in tuber number relative to yield are of great significance for size grade control and reasons for these effects will be examined further.

In terms of the efficiency of light utilisation by the canopy, the provision of irrigation resulted in the production of 1.41 g total dry matter per MJ of intercepted solar radiation compared with 1.23 g/MJ for the non-irrigated plants.

(R. Thompson, H. Taylor and Janet E. Brinklow)

Potatoes — seed tuber preparation

Tecnazene and rindite treatment of tubers prior to planting was again evaluated for increasing stem numbers and seediness in the cultivars Pentland Crown, Pentland Ivory and Maris Piper stored at 9°C from mid-February. Unlike 1980, emergence of shoots from treated tubers was delayed and this, combined with the early senescence caused by drought, caused much reduced yields. Stem numbers averaged over cultivars were increased from 23 stems/m^2 for the untreated controls to 33 stems/m^2 by chemical treatment, which was rather less than last year when a 70% increase was recorded. There was some evidence that Maris Piper was less responsive to chemical treatment in terms of increases in stem number than were either of the Pentland cultivars. Total yields were substantially lower for the treated tubers with 27 t/ha when averaged over cultivars, compared with 36 t/ha for the untreated. The proportion of the total yield in the 35-55 mm size grade was 68% for the untreated controls and 75% for the treated. These values for seed tubers may be as much a result of the differences in total yield as effects of different stem densitiies.

(R. Thompson, H. Taylor, Janet E. Brinklow)

01050 *Control of growth, yield and quality of protein and other seed crops used for feed manufacture*

Field beans — EEC genotype x environment

Genotype x environment interaction has been recorded in the joint field bean test (p. 49). Identification of the environment factors responsible for

the interaction may enable better definition of breeding objectives. This year measured maximum (MM) yield experiments were located at Dijon (France), Wageningen (The Netherlands) and at Mylnefield. The cultivars Aquadulce, Minica, Giza and Herz Freya were chosen for their diversity in morphological characteristics and differences in origin. Soil treatments investigated were measured maximum (MM) yield conditions, irrigated and liquid-fed indigenous soil, and indigenous soil with conventional husbandry. Five harvests were made between mid-May and mid-October and, at SCRI only, light interception was recorded on selected plots from emergence.

Although analysis of the data is not complete, it is clear that interactions between site, genotype and treatment occurred. For example whereas total dry matter production was greatest from the MM plots at all sites, seed yields for the northern European types Minica and Herz Freya were greatest from MM plots at Dijon (34 g/plant) but from the irrigated indigenous soil (20.5 g/plant) at Mylnefield. The Mediterranean types Giza and Aquadulce gave their greatest yield from the unirrigated control plots in Dijon (19 g/plant) but gave poor yields in all three plots treatments in Scotland with a maximum of about 10 g/plant.

Relationships between seed yield and total plant dry weight also differed between sites. This resulted in especially high harvest indices (dry weight of seed: total dry weight) from Dijon of about 0.58 compared with an average of 0.39 from Mylnefield.

Light interception measurements at Mylnefield were used to calculate the efficiency of utilisation as reflected in total dry matter production. The irrigated indigenous soil gave the highest value of 1.03 g/MJ and the least efficient was the MM plot with 0.78 g/MJ. In future years, when intercepted radiation is measured at other sites, more effective interpretation of the results will be possible.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Field beans — EEC joint cultivar trial

The same cultivars were included as last year and the large-seeded types Minica and Wierboon gave the highest yields (15% moisture content) with 6.1 and 5.6 t/ha respectively. The high yield of Minica was accompanied by early maturity, the seed reaching 20% moisture content on 6 September, but Wierboon was the latest to reach this moisture content on 17 September. The small-seeded cultivars Strubes, Diana and Herz Freya were only slightly later than Minica and reached maturity on 8 September when their yields were 5.5, 5.2 and 4.7 t/ha respectively. Analysis of the results of several years of this experiment have shown that Minica was the highest yielding cultivar over a wide range of environments throughout Europe.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Fodder peas — EEC joint cultivar trial

Unlike last year when maturity was delayed by bad weather, seed moisture content this year reached 20% between 23-27 August for all four cultivars, Finale, Amino, Columbo and Maro. Their yields adjusted to 15% moisture content did not differ significantly, and averaged 4.4 t/ha. These results make peas appear an attractive source of seed protein, but the results of last year when seed did not dry sufficiently to be combine-harvested indicate a need for caution.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Field beans — cultivar observation plots

Various breeding lines from the Plant Breeding Institute, Cambridge, Wye College and the Royal Veterinary and Agricultural University, Copenhagen were assessed for maturity and yield. Several 'topless' mutants were included among which were the only lines that were earlier, by up to 10 days, than Maris Bead which reached 20% moisture content by 10 September. Some of these topless lines also gave yields exceeding that of Maris Bead at *ca.* 4.8 t/ha, by up to 1.4 t/ha. The weather this year was particularly suitable for early maturity, and it will be necessary to establish the maturity of the promising lines in a year more like 1980.

(R. Thompson, H. Taylor, Janet E. Brinklow)

01037 *Control of growth, yield and quality of flower bulb crops by cultural methods*

Effect of narcissus yellow stripe virus on crop yield

The effects on crop productivity of the various viruses which infect *Narcissus* have been little studied. In Scotland the incidence of some of these viruses is minimised by a Department of Agriculture and Fisheries for Scotland Certification Scheme based on visual inspection of the crop. One of the viruses controlled by this method is narcissus yellow stripe. To assess the effect of this virus on crop performance, part of a stock of each of the cultivars Helios and Carlton was allowed to become totally infected (grey stock) with narcissus yellow stripe virus and the other part was kept substantially free of this virus (green stock). In a randomised block experiment, bulbs 12-14 cm in circumference were planted in September, 1979, flowers were picked on 2 May, 1980 and the bulbs harvested on 22 July, 1980. Carlton gave a higher yield (25 t/ha) than Helios (23 t/ha) and the rogued stocks (25 t/ha) produced more than unrogued (23 t/ha). However, total numbers of bulbs were greater for the grey (43 bulbs/m^2) than for the green (33 bulbs/m^2) stock of Helios, but the stocks did not differ significantly in this respect for Carlton (average of 34 bulbs/m^2).

The differences in bulb numbers were reflected in the weights of bulbs in the various size grades. for example, yields of bulbs<12 cm in circumference for Helios were 4.5 and 7.7 t/ha for green and grey stocks, and for Carlton were 2.9 and 3.9 t/ha, respectively.

At the other extreme of size, yields of < 17 cm circumference bulbs for Helios were 7.7 and 3.7 t/ha for the green and grey stocks, and for Carlton were 10.1 and 6.7 t/ha respectively. Thus, in general, yields of the premium, larger sized bulbs were greater for green stocks of both cultivars which were therefore commercially superior.

When assessed on 1 May, the proportion of inferior flower stems (shorter than 30 cm) did not differ significantly between the grey and green stocks.

(R. Thompson, W. P. Mowat, H. Taylor, P. Rankin[1])

01014 *Physiological and cultural factors affecting the mechanical harvesting of soft fruits*

Raspberry harvesting

If yield is not to be unacceptably reduced by machine harvesting, two problems have to be solved. The first, that of damage to primocanes with consequent reduction in yield in the following year, appears to have been solved in annually cropped plantations by the catching device designed by the Scottish Institute of Agricultural Engineering and the fungicide spray programme devised by the Mycology Section. Damage is avoided completely in the biennial cropping system, as there are no primocanes present during the harvest operation. The second problem, that of removing and catching a high proportion of the ripe fruit available over the season, requires improved discrimination between ripe and unripe fruit and a more reliable system for catching the dislodged fruit.

In 1980 an inventory was made of all fruits picked and those remaining on laterals after each pass of the Littau machine during the season. The results show that, in cv. Malling Jewel, 60% of the total number of berries present was gathered by the machine, 9% was removed but dropped to the ground, 2% dropped off between picks and 29% was left on the plants at the end of the season. The 60% collected by machine comprised 51% ripe fruit, 6% under-ripe, and 3% mouldy or dehydrated fruit. The berries remaining on the plant after the last pick comprised 8% ripe, 7% under-ripe and 14% mouldy or dehydrated.

In a hand picked crop 80% of the total number of berries was collected, 3% was dropped and 17% remained on the plants when picking ceased. Collected fruit comprised 79% ripe fruit.

In terms of berry numbers, the machine collected 72% of the ripe fruit gathered by hand pickers which is similar to the machine/hand relationship

[1] Department of Agriculture and Fisheries for Scotland.

measured in previous larger experiments where detailed partitioning of losses was not possible.

Measurements of fruit size in this experiment indicated that when harvested by machine, the fruit size of cv. Glen Isla decreased more rapidly as the season progressed than did fruit picked by hand. This decrease was more marked in Glen Isla than in the other two cultivars in the trial. In 1981, a plantation of Glen Isla was picked by the Littau machine and by hand at 2-day and 7-day intervals with the machine picking heads operating at either a high frequency (225 rpm) or a low frequency (160 rpm). At the 7-day picking interval, the pattern of fruit size reduction during the picking season was similar in the hand and low frequency picks but there was an immediate reduction following the first high frequency pick. At the 2-day picking interval there was an earlier reduction in fruit size in the low frequency picks than in the hand, an effect which was considerably exaggerated by picking at high frequency.

Following his visit to SCRI in 1980, E. G. Littau suggested a modification to the Littau machine picking heads to allow the upper fingers to be angled further towards the row than the lower, to provide a better shake for the shorter and more upright laterals near the tops of the canes. This modification was tested on four cultivars, using a relatively light shake. No significant improvement in fruit removal was recorded.

In this very dry picking season, high quality samples of ripe fruit were picked by machine even at the end of the season. This was particularly true of Glen Prosen and seedling 7133R40.

A single pass of the machine was used to assess fruit removal in four cultivars and seven seedlings at four shaker frequencies. Greater numbers of both ripe and green fruits were removed as the vigour of shake was increased. However, the increase in the proportion of green fruit removed was less in some genotypes than in others which suggests that breeding could improve this aspect of machine harvestability.

The problem of dropped fruit was examined in a plantation of Malling Delight growing on the biennial system. When the fishplates of the Littau harvester were run along the line of fruiting canes clipped tightly between two lower wires, only 7% of the fruit removed was dropped compared to the 15% dropped when the fishplates were lowered and forced further apart by the width of the row.

(M. R. Cormack, D. T. Mason)

01018 *Control of growth, yield and quality of raspberries by cultural methods and choice of genotype*

National Fruit Trial (NFT) 1980

Establishment of this trial was rather variable and some gapping-up was necessary.

Considerable damage was caused to young laterals by air frosts of −1.2°C

on the night of 3 March and −3.3°C on the night of 23 April. This and the less than satisfactory establishment were mainly responsible for the low yields compared to the previous NFT trial at a similar stage. The heaviest yield of fruit, which was of very good quality, was picked from seedling 7515C5. Many of the new seedlings are large-fruited, but 7331/1 and 7331/7 were particularly notable in this respect.

(M. R. Cormack)

01019 *Control of growth, yield and quality of strawberries by cultural methods and choice of genotype*

Cultivars from the Pacific Northwest

Two of the four replicates in this trial of red-fleshed cultivars were defoliated immediately after the 1980 harvest. Defoliation increased the yield of Troubadour by 30% and decreased that of Northwest by 30% but had little effect on the yield of the other cultivars. Defoliation increased fruit size in all cultivars except 69GU94 from about 3% in the case of Shuksan and Jurica to 33% in the case of Olympus, but had little effect on the number of primary crowns per plant, continuation shoots or primary trusses per crown. Higher crown numbers were generally reflected in higher yields per hectare.

The early establishment problems appear to have been overcome and most cultivars yielded heavy crops of good quality fruit. The lightest crop, 13 t/ha was picked from Totem but all other cultivars outyielded the 14 t/ha of Cambridge Favourite and Hood. The heaviest yields were produced by Jurica (28 t/ha), 69GU94 (25 t/ha) and Olympus (24 t/ha).

(M. R. Cormack)

01012 *Ecology of new fruit crops in Scotland*

Rubus species

As in previous years, Ashton Cross produced the heaviest yield of fruit (20 t/ha). Its mean berry weight was slightly higher at 2.25 g than that of *R. distractiformis* at 1.95 g which cropped at nearly 16 t/ha. The first few fruit from Bedford Giant planted in 1980 had an average weight of 3.39 g, but the largest fruit weighing an average of 7.75 g was picked from the Tayberry-type hybrid 74158A7. Picking of Tayberry started 22 July, Bedford Giant 10 August, Ashton Cross 24 August and *R. distractiformis* 28 August.

Vaccinium species

The established blueberry plants were pruned in March, 1981 for the first time since 1975. Records of pruning weights and plant sizes showed similarities which confirmed that the early differences in growth due to the pre-planting soil treatments had disappeared.

Mentha species

M. rotundifolia (applemint) yielded 55 t/ha of green straw, *M. piperita* (peppermint) 23 t/ha, and *M. x gentilis* (spearmint) 22 t/ha. Oil was distilled by Dundee College of Technology from wilted straw of the latter two species. Yields of oil were calculated as 32 kg/ha from *M. piperita* and 42 kg/ha from *M. x gentilis*. These are typical of yields in the UK and some areas of the USA but are only about half those achieved in Washington and Oregon.

(M. R. Cormack)

Windbreaks

Leafing-out times and growth rates were recorded in three experimental windbreaks. In the poplar windbreak planted in 1979, increases in height ranged from about 25 cm *(Populus simonii, P. koreana* and *P. berolinensis)* to about 90 cm *(P. canescens macrophylla* and *P. tacomahaca* x *trichocarpa* 32).

All the willow species planted in 1975 grew more than 50 cm in height during 1981 except *Salix alba steinach* 33, which was relatively slow growing and shrubby and therefore unsuitable as a windbreak tree.

Growth rates were more modest in the windbreak of different tree types planted in 1971. The tallest trees, *P. x generosa* reached a height of 13 cm. *Salix alba coerulea* grew to 9 m and *Cupressocyparis leylandii*, to just under 7 m.

(M. R. Cormack)

STATISTICS AND COMPUTING

01044 *Statistics (service)*

Programs were written for the Apple microcomputer for simple analysis of variance and regression, using some of the routines developed at Pentlandfield for data entry.

A project in the Mycology section studied the effect of certain nutrients on the response of bacteria to the phytoalexin rishitin. Respiration was monitored using an oxygen electrode and a chart recorder. The shape of the curves suggested that a first order differential equation could be used to describe respiration and programs were written to digitise the traces using the Tektronix 4051 and to quantify the interaction between rishitin and the nutrients.

Stereological techniques were applied to estimate volume fractions of the oesophageal bulb of *Xiphinema index*. Results using the point lattice were verified using the digitiser; the data were analysed using GLIM and a binomial link function. Similar studies were undertaken for root cell components, comparing normal roots and those galled by *X. diversicaudatum* and *Longidorus elongatus* for volume fraction and cell surface area.

Canonical variate analyses were used in various fields, in microbiology, in seed morphology and in nematode morphometrics.

In conjunction with Dr Bello's[1] visit, four major studies of nematode ecology in Spain involved the analysis of data from over 1600 soil samples. In most cases the nematofauna of the forest ecosystems natural to the areas concerned was studied in relation to that of the cultivated areas. When the ecological studies are completed, the material will form part of the Spanish contribution to the data bank of the European Plant-Parasitic Nematode Survey.

(Pauline B. Topham, J. B. Cowan)

01045 *Computing (service)*

Edinburgh Regional Computing Centre facilities

The greatly increased use of the Edinburgh mainframes (Table 1) means that running this service is taking up an increasing amount of time; it has mainly come from non-numeric computing such as information retrieval and cataloguing. Much advisory and tutorial effort is required to make new users familiar with the system, the various packages and with the facilities available locally. Courses have been given locally on Genstat, the Edinburgh Multiple Acces System (EMAS) and the microcomputer facilities.

The move away from card-punching to data entry via microcomputers will be increased following the purchase of an Apple II in the autumn. Users increasingly prefer to edit and manipulate computer files rather than handle cards. Similarly the Visual Display Terminals (VDTs) are now preferred. To help users get the best out of differing terminal types a routine has been written which sets up the right modes of operation for users. Occasionally it is a disadvantage not to have a permanent record of the contents of the VDT screen; an EMAS command HARD has been written to send a copy of the EMAS dialogue for a session to the line printer.

(R. J. Clark, J. B. Cowan, Pauline B. Topham)

The Microcomputer facilities

The System One has been extremely heavily used; 47% of the occasions of use involved text-processing and some applications had to be restricted to less popular periods of the day. It is also becoming difficult to fulfil all the demands upon it for data logging. It has also been much used for data entry (28% of occasions of use) and as an intermediary for transmission of data from the Tektronix 4051 to EMAS, following the writing of two BASIC programs to control data transfer. It was also used to process meteorlogical

[1] Instituto de Edafologia, CSIC, Madrid.

data and to calculate accumulated day degrees, whilst users continue to write small BASIC programs, for example, to tabulate date.

The Tektronix 4051 was also used more heavily than last year, largely for routine digitisation. Among the less routine users were 3-dimensional reconstructions of the oesophageal bulb in *Xiphinema index* and the calculation, from traces of longitudinal sections, of its volume and that of associated structures. It was also used to assess two small interactive programs for non-linear curve fitting and to display the results.

(J. B. Cowan, R. J. Clark, Pauline B. Topham)

Programs for computer-aided identification of nematodes

To assist morphometric comparisons of samples of nematodes with specific standards for identification, a suite of BASIC programs has been written for the Tektronix microcomputer/digitiser. The approach is general so that they may be used in the future for different genera or even other groups of organisms.

The facilities available are called by a small interactive steering program. Characters may be defined as categorical, numerical or metric, and a reference file of data values for known species may be set up. Data from samples which are to be identified may be acquired as lengths, traces or areas from the digitiser, or entered via the keyboard. Taxonomic ratios may be calculated and summary statistics for the sample produced. When identification is requested a list of species with fewer than a specified number of character mismatches is displayed.

The program is being tested on the genus *Heliocotylenchus* with 109 species and 26 characters.

(P. Smith[1], B. Boag[2])

Information Retrieval

Many more users have had their personal bibliographies keyed in to EMAS this year. Several groups of users are keeping communal catalogues of group holdings of reprints, for instance the potato physiologists and the nematologists. CATALOG, the information retrieval system written at the ERCC by M. J. Cross, has been helpful both as a fast interactive package with simple commands and as an introduction to EMAS for certain users. Furthermore it can be used in conjunction with FAMULUS since the record structure is the same.

Magnetic tape copies of the Black Currant Bibliography were sent to East Malling Research Station and Loughborough in England and printouts to workers in Australia, Canada and New Zealand.

(R. J. Clark)

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[1] Plant Breeding Section
[2] Zoology Section

TABLE 1 — COMPUTER USAGE, 1981

	2980 Occasions of use	%	Tektronix 4051 Hours	%	System One Hours	%
Crops Research	1750	19.6	110.2	17.6	176.4	16.8
Mycology	668	7.5	51.0	8.1	138.6	13.2
Plant Breeding	1609	18.0	110.5	17.6	202.8	19.3
Virology	439	4.9	73.9	11.8	364.4	34.7
Zoology	1901	21.2	268.8	42.9	155.4	14.8
Statistics group	2580	28.8	—	—	—	—
Others	—	—	12.0	1.9	13.5	1.3
Total 1981	8947		626.4		1051.2	
Total 1980	2727		462.5		426.8	
% increase	228		35.0		146.0	
Use per working day (1981)	35.8		2.5		4.2	

PLANT BREEDING

D. L. JENNINGS

This is the first year since 1941 that no strawberry crosses were made. The winding down of work at the West of Scotland Unit proceeded throughout the year with emphasis on measures to safeguard the strawberry germplasm. R. J. McNicol continued to co-ordinate the trialling of all strawberry material of cultivar potential, and he will retain this responsibility at Invergowrie in addition to his new involvement in the raspberry breeding programme.

Two notable successes during the year were the very high yields obtained by some advanced black currant selections, especially from small-bush types planted at high density, and the good performance of two late-maturing cabbage hybrids. The latter have now been entered for NIAB performance trials and national listing.

Good progress was also made in studies of the incompatibility system of brassica crops: a method was developed for separating and assaying stylar components which inhibit pollen tube growth, though none of those studied could be associated with the incompatibility mechanism, and aneuploids were produced to identify the chromosome bearing the *S* locus. Genetic studies have now been extended to forage brassicas, notably *B. campestris*.

03001 *Strawberry: breeding and associated genetic studies*

The strawberry breeding programme has now been terminated and no crosses were made in 1981. Open-pollinated seed was collected from each genotype in the SCRI germplasm collection to minimise the risk of loosing genetic material. One half of each sample was sent to Long Ashton Research Station and the other half is being retained at SCRI.

All selections showing cultivar potential were transferred to Invergowrie for further evaluation. Notable amongst these are WC64, a cv. Sengana Sengana derivative, and ET115A, a cv. Gorella derivative, both of which are particularly suitable for processing and give acceptable canned products either with or without added dye. Another leading selection is GU94 which is particularly suitable for freezing when diced and sliced. These selections are being propagated by tissue culture to provide plants for commercial appraisal in the United Kingdom and France.

Disease resistance

The parents and progenies of a partial half-diallel were assessed for the incidence of post-harvest fruit rots caused by *Botrytis cinerea, Rhizopus* spp. or *Phytophthora cactorum*. Estimates of general and specific combining abilities were calculated and phenotypic assessments were obtained for the 17 parents. Cv. 'Tyee' was found to be the best source of resistance.

Fruit quality

Fruit of four cultivars and 19 selections were assessed for quality after they had been blast frozen and stored in a domestic deep freeze. Replicated determinations after 24 hours of thawing showed that selection ND9 was outstanding. It had only 10% drip loss, compared to 27% for Cambridge Favourite, and its colour was much darker, having an L value of 24.5 compared to 35.2 for Cambridge Favourite.

(R. J. McNicol)

03006 *Cane fruit: breeding and associated studies*

Assessments of advanced selections were seriously affected by damage to flower buds by late spring frosts. Some useful information on spring frost tolerance was gained in one experiment, and the good tolerance of an early selection related to a hybrid bred in New York was identified. Several of our selections in the National Fruit Trial were promising in their first fruiting year, but in some instances the frosts also caused excessive primocane branching, resulting in poorer fruiting canes for 1982.

Yield studies

Further study of variation in the number of nodes present on primocanes was made in 14 families planted in 1979. Highly significant differences in the numbers of nodes present were found and attributed entirely to additive effects of the 10 parents involved. The parent which contributed most to high node number was 7538A10, which, like 7325C4 identified in 1981, is derived from the German cv. Rumilo. The relationships between node number, cane diameter and cane height were less clear than those found in the study described in the 1980 report, probably because the plants were newly established.

(D. L. Jennings, A. Dale, Eleanor Carmichael, Barbara M. M. Tulloch)

The inheritance of relationships between various morphological characteristics of laterals was studied in six outcrossed families of a diallel. The lateral characteristics were measured by vectors obtained from a principal component analysis. The first vector described general lateral

vigour (Ann. Rep. 1978, p. 57) and the second described reproductive vigour, i.e. an association between high values for the number of flower buds per lateral, the proportion of lateral nodes with buds or fruit, the number of lateral nodes with more than one flower bud and those with two or more fruits, and low values for lateral length, diameter and the number of nodes on the lateral. Both general lateral vigour and reproductive vigour were inherited additively, though there was significant special combining ability for general lateral vigour.

Scores for the two vectors were compared with flowering dates in the six families. This showed that plants with highly reproductive laterals flowered relatively early in each family and those with strong general lateral vigour flowered significantly later in two of them. The latter relationship was also found in two other experiments. In the diallel, three of the four families where general lateral vigour was not related to flowering time had a common parent. This parent, a derivative of cv. Carnival, may therefore have contributed a factor which caused the laterals to be more vigorous than expected from their flowering date; early bud burst is a possibility.

(A. Dale)

Genotype x environment inheritance of yield component studies

Studies of growth and productivity of American and British cultivars at SCRI and Abbotsford, British Columbia were continued. At SCRI frosts in late April killed many flower buds and young canes.

In both 1980 and 1981, yield differences between cultivars could be associated with differences in cane diameter. In both years the cultivars with thick canes gave the highest yields at SCRI. At Abbotsford in 1981, Malling Jewel and Leo yielded much less than the other cultivars, even though their fruiting canes were thicker. This was probably because they averaged only five laterals per cane compared with nine or more for the others.

(A. Dale, H. A. Daubeny[1], Barbara M. M. Tulloch

Disease and pest resistance

In further experiments using mycelial inocula to evaluate resistance to *Botrytis cinerea* and *Didymella applanata*, five canes per genotype were separately inoculated with each pathogen, and resistance was assessed from the size of the resultant lesions after 4 weeks. Highly significant genotypic correlations were obtained between the resistances to the two pathogens regardless of whether the resistances were derived from Malling 1473/35 ($r = 0.57$; d.f. = 243), *Rubus pileatus* ($r = 0.45$; d.f. = 122), *R. coreanus* ($r = 0.50$; d.f. = 33) or *R. occidentalis* ($R = 0.83$; d.f. = 22). There were no within-plant correlations between the two resistances.

[1] Agriculture Canada Research Station, Vancouver, Canada.

The inheritance of each resistance was entirely additive and there were no interactions when resistances from more than one source were combined; the correlation between the mean resistance of progenies to *B. cinerea* and the mean resistance of their parents was therefore very high ($r = 0.93$; d.f. = 17). No evidence of major gene inheritence was obtained. Thus all the evidence indicates that breeding to improve resistance to these two pathogens will be straightforward, and that selection for resistance to *B. cinerea* will also result in improved resistance to *D. applanata*.

Experiments in 1980 and 1981 using mycelial inocula of *Leptosphaeria coniothyrium* showed that gene *H*, which determines cane hairiness, also confers a small but significant resistance to this pathogen. Thus there is now evidence that the gene is associated with strong tissue resistance to *B. cinerea* and *D. applanata*, small but significant improvements in the resistance of the fruit to *B. cinerea* and of the canes to *L. coniothyrium* but low resistance to *Elsinoe veneta* and *Sphaerotheca macularis*.

(D. L. Jennings, Eleanor Carmichael)

Natural splits on raspberry primocanes in spring and the subsequent peeling of the rind (primary cortex and epidermis) predisposes the canes to attack by cane midge *(Resseliella theobaldi)*. No rind peeling was observed on *R. crataegifolius* or on most of its F_2 hybrids with raspberry and it seemed likely that this feature could explain a report of the species' resistance to the pest in Russia. Periderm formation at natural splits was therefore studied histologically in *R. crataegifolius*, the F_2 hybrids and cv. Glen Clova which has conspicuous cane splits. In *R. crataegifolius* an extensive wound periderm of suberised cells was observed in the cortex beneath very small epidermal splits, while in Glen Clova the cortical cells were not suberised and the inner cortex separated from the periderm when the stem polyderm (multiseriate periderm) matured. Cortical cells in the hybrids showed intermediate suberisation and an abundant wound periderm occurred around natural splits which were much deeper than in *R. crataegifolius*. The latter probably causes the reticulate stem markings which are characteristic of these hybrids. The F_2 hybrids were sub-fertile and segregated for this stem feature; a backcross to the raspberry was therefore made to combine improved fertility with a strong expression of the *R. crataegifolius* stem type.

(D. L. Jennings, B. Williamson[1])

Tissue culture

Meristem cultures of the cultivars Glen Prosen and Glen Moy and the raspberry selection M30 were established on four different kinds of media recommended for *Rubus* by other workers. The most successful media was

[1] Mycology Section.

that of M. Caine *et al*, Dijon, France (Bull. Petits Fruits, No. 14, March 1979), and the cultures of Glen Prosen and Glen Moy grew considerably more slowly than those of M30. Two cultures are now being propagated by micro-cuttings and some 200 plants of each will be field planted for comparison with stocks propagated by root cuttings.

(R. J. McNicol, Eleanor Carmichael)

03008 *Cane Fruit: breeding early erect blackberries and other* Rubus *fruits*

Selections with excellent productivity and fruit quality were obtained from progenies of spine-free blackberries in which spinelessness is conferred by a recessive gene, but slow ripening was again a serious shortcoming for production in Scotland. Rapid ripening and hardiness were therefore the two characters emphasised in the choice of parents for further breeding.

Several large populations were established of spine-free material carrying the dominant gene for spinelessness originally introduced from the octoploid cv. Austin Thornless. In progenies derived from raspberry x blackberry hybrids and mainly hexaploid, the proportions of spinefree plants were 31% in 388 progeny of one pollen parent and 44% in 823 progeny of another; both of these parents failed as maternal parents. In tetraploid blackberry progenies the proportion was 51% in 301 progeny. Thus the gene segregated freely at each level of ploidy but departed from the 1:1 expectation in the sub-fertile hexaploids.

(D. L. Jennings, Eleanor Carmichael)

03009 *Bush fruits: breeding black currants for northern regions of the UK.*

Plant habit and yield

For most fruit crops closely planted small-bush cultivars have the potential to yield more per unit area than traditional cultivars planted at conventional spacings. Selections of wild nordic black currants lend themselves to the production of small-bush hybrids suitable for close hedgerow planting in 1.8 m rows. Such hybrids are adapted to long days and high latitudes and their tolerance of frost and cold ensures regular cropping. Three problems impede their immediate commercial exploitation; their plant habit does not suit the available machine harvesters, their juice processing quality is inferior, and they have a restricted season of ripening. These problems can be solved by further breeding, but the best plant form needs to be determined for machine harvesters modified to pick small closely-planted bushes. Small-bush hybrids are being propagated for this purpose.

The SCRI 238/36/19 x Ben Lomond hybrids selected in 1977 were outstanding at conventional spacings for their combination of high yield and high berry weight (1.3-1.9 g) and one of them had a distinctly better plant

form than its parents. The high harvest index of small-bush hybrids was also evident in second-stage plots of frost and cold tolerant selections obtained from crosses between 238/36/12 and either Ben Lomond or Black Reward and between 238/36/19 and Westra. Further improvements in plant form, juice processing qualities and disease resistance are required in these hybrids, and donor parents with the necessary combination of attributes have been selected.

Regional trials and commercial assessments

During the 6 years from 1976-81 at Luddington EHS, SCRI 238/36/19, a small-bush, early maturing sister seedling of cv. Ben More averaged 15.9 t/ha at 2.7 x 0.4 m spacing. The corresponding yields of the cultivars Ben More, Black Reward, Ben Lomond and Baldwin were 12.2, 11.2, 11.3 and 9.1. The three highest yielders showed an interesting contrast in plant size: SCRI 238/36/19 formed a small, compact plant less than 1 m tall, which characteristically bore about the maximum amount of fruit possible, while Ben More and Black Reward formed conventional, moderately vigorous bushes. SCRI 238/36/19 was also notable for its high harvest index, consistency of cropping and large berry size, but it had poor juice processing qualities. It was not suitable for machine harvesting by available harvesters but clearly showed the potential of plants of this type for high density hedgerow planting at close inter-row spacings.

At NFT Brogdale, five SCRI hybrids gave twice the yield of Baldwin, and five others, including Ben Lomond, 1.5 times its yield.

Further evidence that large bush size is not needed for high yield was obtained at SCRI, where 50 plants of Ben More in their second year of cropping and spaced at 2.4 x 1.2 m yielded the equivalent of 25 t/ha. Although the branches were borne down by the weight of crop they resumed an upright stance after harvest. This emphasises the value of Ben More for breeding, because it also contributes a high tolerance of spring frosts, late flowering but relatively early ripening, and a growth habit with a good balance between vegetative and reproductive vigour. Compared to Baldwin its juice colour and flavour is superior and its ascorbic acid content is lower.

Improved fruit setting at sub-optimal temperatures

Two causes of poor fruit set are low (non-freezing) temperatures at the grape stage or during the periods of pollination and fertilisation. From 1971 to 1981 at Brogdale NFT the mean daily maximum and minimum temperatures between grape and full flower stages of Baldwin averaged 12 and 4°C respectively; these are below the optimum temperatures for the pollination and fertilisation of European cultivars, which are reputed to be 14-16°C, with pollination inhibited at *ca.* 10°C and pollen tube growth stopped at 6°C. Greater tolerance of the latter temperatures is therefore an

important requirement for regular cropping and it is likely to be found in wild black currants from arctic environments in nordic countries, the USSR and northern Canada. In particular, there is interest in arctic wild types which form sparse-flowering, dwarf or semi-dwarf bushes under UK conditions. These include the cultivars Sunderbyn II, Matkakoski, Melalahti and Jankisjarvi. Selected hybrids from crosses of P10/8/2 x Sunderbyn II, P10/8/2 x Matkakoski, Ojebyn x Matkakoski and cv. Merveille de la Gironde x Sunderbyn II showed useful combinations of attributes, including good fruit set. The cultivars Prima (USSR), Stripta (Germany) and Melalahti (Finland) were also notable for their frost tolerance at flowering and their ability to set short but fully furnished strigs. Melalahti formed a small, erect bush with large berries in which flowering was confined to a few nodes immediately below the terminal buds.

Approximately 10% of the frosts experienced in England are wind rather than radiation frosts. Early leafing and large leafy bracts which enclose the emerging flowers are protective, insulating traits which protect the flower buds from wind at grape stage and during early flowering. An extreme expression of them was identified in a late flowering hybrid between P10/8/2 and a cv. Westra x *Ribes sanguineum* hybrid and is being used in further breeding.

(M. M. Anderson)

Frost tolerance

Dormant flower buds of the cultivars Baldwin, Ben Lomond and Ben More were frosted to *ca.* −20°C on two dates in February. In the first test, most buds of Ben Lomond and Ben More survived −19.5°C and threequarters of the Baldwin buds were killed. In the second test most buds of Ben More survived −21°C for 1 hour but only half the Ben Lomond buds and no Baldwin buds survived. No vegetative buds were killed in either test. Thus the ranking for tolerance of winter frost was Ben More, Ben Lomond, Baldwin, which is the same as that for their tolerance of spring frost. This suggests that spring frost tolerance may be associated with winter frost tolerance.

The spring frost tolerance of the same three cultivars was compared using plants and cut shoots. Comparisons were made between cut shoots frosted in buckets or vacuum flasks, in water or nutrient solution and left dry or wetted before treatment. Samples of both the plants and the cut shoots were frosted to −4.6°C for 4 hours every 2 days, starting from before bud burst. The most buds and flowers were killed on cut shoots which were in the flasks and wetted. For comparable treatments the numbers of flower buds killed were similar for plants and cut shoots. Most of the flower buds of Baldwin were killed by the treatment shortly after the grape stage, whereas buds of Ben Lomond and Ben More were only killed by treatments from 4-6 days after first flower.

(A. Dale, Barbara M. M. Tulloch)

Premature Fruit Drop

The presence or absence of fruit at each position on the raceme was recorded for 50 racemes of eight genotypes to determine where fruit had been lost. In all genotypes most fruit had been lost from the tips of the racemes, but in Baldwin, Black Reward and 243/7 some fruit had also been lost from the bases. A natural frost on 22 April had killed more flowers in these three genotypes than in the others, and it is probable that losses due to this cause were in the basal half of the racemes.

(A. Dale)

Branch strength and flexibility

Cultivars such as Silvergieter's Black which have rigid branches are prone to machine harvester injury. The flexible branches of hybrids of cv. Goliath, including the cultivars Ben More and Roodknop, tend to escape this type of injury, but lack the strength to hold heavy crops in a posture suitable for machine harvesting and subsequent mechanical pruning. Ben More is a good parent for breeding conventional bush types, but further trialling of small-bush hybrids is needed to determine the best combination of strength and flexibility for short-statured branches. Hybrids varying widely in these two qualities were selected from progenies of P10/8/2 x Sunderbyn II, P10/8/2 x Matkakoski and from a complex Ben More progeny which segregated for plants with strong, upright, freely-spurring branches.

Juice quality

The combination of high berry weight with good juice processing qualities is particularly valuable, because principal component analysis has previously shown that the natural trend in SCRI hybrids is for high juice colour and high content of ascorbic acid corrected for specific gravity (AAsg) to be associated with low berry weight. Among the best 10% of hybrids assessed for juice colour, were four with berry weights ranging from 1.25 to 1.47 g (max. observed = 1.98) and AAsg values ranging from 73 to 104 (max. observed = 157). These hybrids are derivatives of Ben Lomond or its sister seedling 93/28. However, seven 238/36/19 x Ben Lomond small-bush hybrids selected for agronomic merit had poor colour. Prominent among potential small-bush cultivars and highly coloured juice were P9/13/12 (238/36/12 x Westra) and P9/11/14 (238/36/12 x B. Lomond); both of these have frost tolerance, good fruit setting and large berry size. Three other selections were also rated highly: two of them will crop at Brogdale NFT in 1982, and P9/8/7, a late maturing Ben Lomond hybrid is under consideration for commercial release.

The flavour of 27 SCRI juice samples was judged by an experienced taste panel at Beecham Products. A sample of Baldwin was rated '5' to allow improved juices to be scored higher. In contrast with 1979, the flavour scores obtained were not correlated with AAsg. Principal component analysis

similar to that previously described (Ann. Rep. 1980, p.61) were done but excluding copigmentation index. Whereas in 1979 it was found that high flavour ratings were associated with high AAsg in each of the first two vectors, in 1980 only the second vector showed this association. Ben More, Baldwin, P9/8/7 and 243/7 scored highly for the second vector.

Of seven hybrids rated equal or superior to Baldwin for flavour, Ben More scored highest('6'), followed by an early-maturing complex hybrid of *R. nigrum*, *R. dikuscha* and *R. bracteosum*, 243/7 and a *(R. nigrum* x *R. dikuscha)* x Westra hybrid. The others were derivatives of Ben Lomond, including P9/8/7 and F6/3/39, which have dominant 'catty' flavours suitable for blending.

Four of the hybrids, including 243/7 and P9/8/7, had good combinations of all juice qualities including flavour. Westra x 243/7 hybrids had good colour and flavour, but Westra x 238/36/12 hybrids were only moderate in these respects.

(M. M. Anderson, Judith Thomson)

Esterase isoenzymes

Isoenzyme assays were explored in black currants to seek suitable systems for cultivar identification and recognition of rogues, and as an aid to genetic studies. Leaf extracts required considered purification to overcome problems of streaking and poor band definition when stained for esterases following polyacrylamide gel electrophoresis. Selfed seedlings of Ben More segregated putative allozyme bands detected approximately 20 mm from the sample origin after electrophoresis for 1 h. The enzyme appeared to be dimeric and segregation in the cross Ben More x Ben Lomond suggested that Ben Lomond was homozygous for the fastest allozyme.

(Eveline M. Wiseman)

03010 *Brassicas: genetics of S-allele incompatability systems in* Brassica oleracea

Nature of the incompatibility reaction

Further isoelectric focussing experiments of *B. oleracea* stigmatic homogenates were done to detect glycoproteins linked to or specific to incompatibility alleles (Ann. Rep. 1980, p.68). Different protein concentrations and staining conditions were compared and the best results were obtained by using 30 stigmas ground in 150 μl 0.01 M phosphate buffer, pH 7, centrifuged and loaded on paper wicks. Many well-defined protein bands and three faintly stained glycoprotein bands were observed on acrylamide gels but it was not possible to establish a correlation between band position and S-allele genotype.

The chromatofocussing technique, which separates proteins according to their isoelectric points by column chromatography, was used in two

experiments. The quantities of tissue used in the first experiment were found to be inadequate and the method used to purify the extract failed to remove some soluble compounds that interfered with protein identification. In the second experiment 1700 stigmas (0.54 g) from mature flowers and 4100 immature stigmas (0.53 g) from buds were ground in buffer and low molecular weight substances were removed by running the supernatant over Sephadex G10. Optical density measurements at 260 nm and 280 nm of the eluted fractions revealed major differences between the two samples but technical difficulties prevented further characterisation. In view of the labour involved in obtaining sufficient material for analysis this work was discontinued.

The possible presence of stylar components which inhibit pollen tube growth in a manner analogous to phytoalexins in plant fungal defence mechanisms has been further investigated. Conditions were defined under which pollen of *Petunia hybrida* and *Lilium lankongense* would readily germinate after being sprayed onto silica TLC plates. Attempts to germinate *B. oleracea* pollen under such conditions have so far been unsuccessful, although this is not surprising because satisfactory conditions for the successful germination of *B. oleracea* have yet to be defined. However, pollen from *P. hybrida* and *L. lankongense* has been used to investigate the presence of germination inhibitors. Self-or cross-pollinated *B. oleracea* stigmas (0.1 g) were collected together with similar quantities of unpollinated stigmas and pollen. The ethyl acetate soluble fraction of the stigma or pollen extracts was subjected to chromatography on silica TLC plates in methanol and chloroform (5:95). After drying the plates were sprayed with *P. hybrida* or *L. lankongense* pollen, incubated for 6-8h, dried again then sprayed with alkaline aniline blue.

When examined under UV light (360 nm) a number of zones in which pollen germination was inhibited were found as non-fluorescing spots on the TLC plate. Microscopic examination confirmed that pollen in these areas had failed to germinate and precise measurements of the dimensions and positions of such zones were obtained from counts of germinating grains. Pollen extracts gave a different pattern of inhibitory zones from the three stigma extracts, which themselves showed some differences, the details of which have yet to be resolved. *P. hybrida* and *L. lankongense* pollen appeared to have identical patterns of inhibition suggesting that the substances involved are general pollen inhibitors. The assay has shown that *B. oleracea* stigmas contain substances which inhibit pollen tube growth, although no substance unique to incompatibly pollinated stigmas has yet been identified.

(T. Hodgkin, Eveline M. Wiseman, G. Lyon[1])

[1] Mycology Section.

Plants suitable for self-incompatibility research

Additional rapid flowering *B. alboglabra* lines have been obtained from a number of sources and S-allele homozygotes isolated. Five S-alleles and one self-compatible line, showing no S-allele activity, are now available which flower in 60-100 days from sowing. More crosses between S-homozygotes and male cyto-sterile plants have been made (Ann. Rep. 1981) and male-sterile S-homozygotes will be available in 1982.

(T. Hodgkin)

03011 *Brussels sprouts: breeding hybrid cultivars*

Yield components and internal browning

The parents of those progenies which gave the highest yields and most uniform sprouts in 1980 (Ann. Rep. 1980, p.64) were self pollinated. Owing to poor vernalisation of the parent plants seed production was low and it will be necessary to carry out further pollinations during 1982.

A trial of progenies with a high level of internal browning (IB) showed that there was considerable plant to plant variation even in the most susceptible ones. They were obtained from a complex series of crosses and are presumed to be highly heterozygous. It is desired to make avaiiable uniformly susceptible lines for use as testers and experimental controls when this work is terminated, and a programme of rapid inbreeding has been started, using single seed descent, to produce such lines as soon as possible.

(T. Hodgkin)

Improvement of glossy inbred lines

The third cycle of the single-cross selection experiment was represented by 65 hybrid progenies, each produced by crossing two inbreds homozygous for complementary glossy foliage genes (Ann. Rep. 1980, p.64), which were grown in a replicated trial with the F_1 hybrid control cultivars Lunet, Merlon, Tornado and Viscount. Dry conditions in August and September, and heavy infestation by aphids, resulted in relatively poor growth in this and other *Brassica* experiments.

Harvests were made in late October and early December. Yields and quality were better at the later harvest and there was little evidence of frost damage. Final analysis of yield and quality data is not yet complete.

(A. J. Redfern)

03012 *Cabbage: breeding hybrid cultivars*

Satisfactory quantities of seed were obtained from small-scale productions of the two autumn-maturing hybrid savoys C6077 and C6693 currently undergoing National List trials. These productions did not reveal any potential problems for larger-scale productions. However, one parent of C6077 is maintained as two near-isogenic lines with different incompatibility

alleles and the first multiplication can be done by insect pollination instead of by hand. Consequently, it is expected that seed of C6077 can be produced more readily and cheaply than seed of C6693. Because differences between the two cultivars are relatively small it has been decided not to proceed with C6693.

Sixteen savoy and 10 Celtic-type hybrids, selected in 1978 and then multiplied by blowfly pollination (Ann. Rep. 1980, p.65), were grown at Mylnefield and some were also grown at Stockbridge House EHS. It was not possible to determine sib levels in any of these hybrids by isoenzyme analysis although field plots indicated levels ranging from 2-15%. Two later maturing hybrids (C9112 and C9392) were selected from the trials and entered for National Institute of Agricultural Botany performance trials and national listing in 1982.

Nineteen savoy and Celtic-type hybrids, including C9112 and C9392, were multiplied in 12-plant cubicles using blowfly pollinators. Improved pest and disease control and better ventilation resulted in higher seed yields than were obtained when these facilities were first used in 1980.

Replicated trials of 26 savoy and 19 Celtic-type hybrids selected from an earlier unreplicated trial (Ann. Rep. 1980, p.66) were harvested in the autumn and assessed for quality and yield performance. Assessment of the plots retained for evaluation of winter-hardiness is not yet complete but most hybrid savoys were still in marketable condition at the end of December.

Over-wintered inbreds were assessed for their suitability as parent material. Extreme responses were noted in the extent of lodging and susceptibility to *Alternaria brassicicola* enabling selections to be made against these and other deleterious characters.

(A. J. Redfern, A. B. Wills)

03013 *Brassicas: isoenzyme analysis in* Brassica oleracea

Characteristic protein differences, including isoezymes, that can be detected readily among different species would be a useful aid to the analysis of introgression during species improvement. Therefore experiments were started to define the optimum conditions for SDS-polyacrylamide gel electrophoresis of soluble proteins of *B. oleracea*. Seed extracts gave many clearly defined protein bands, only few of which had mobilities corresponding to those of the less well resolved leaf extracts. No differences were found between several genotypes in either seed or leaf protein banding patterns.

The survey of acid phosphatase isoenzymes in *Brassica* species was continued. Acp-1 was analysed in seeds of 28 *B. campestris* cultivars, including turnip, Chinese cabbage and oilseed rape, obtained from British, Dutch, American and Japanese sources. Eight allozyme bands were recognised, having mobilities 0.285, 0.30, 0.31, 0.315, 0.32, 0.33, 0.34, and

0.36 relative to brilliant yellow. The tetraploid cv. Appin had some seeds with three bands. In *B. campestris* the bands presumed to be due to Acp-3 allozymes have a much wider range of mobilities than those of *B. oleracea* (Ann. Rep. 1980, p.67) and a total of 10 has now been recognised. The analysis of progenies from crosses between plants with known banding patterns, to confirm allelism, is not yet complete.

(Eveline M. Wiseman, A. B. Wills)

03015 *Brassicas: genetics and cytology of* Brassica oleracea *in relation to linkage groups*

Tetraploidy was induced by colchicine treatment in *B. alboglabra* seedlings heterozygous for co-dominant incompatibility alleles. These were then crossed to diploids, homozygous for a third S-allele, to produce triploids. Further crosses are expected to yield aneuploids among which trisomic plants can be recognised expressing three S-alleles, to enable the chromosome bearing the S-locus to be identified. Further crosses have been done with previously produced trisomics to incorporate a number of marker genes.

A total of 40 families, raised in a glasshouse or observed after overwintering in the field, segregated for 36 markers in 146 combinations. No new seedling markers were introduced but segregation ratios for polycotyledony (po) were consistent with control by duplicate genes. Fused cotyledon (fc) behaved similarly. Of particular interest was one family of 104 seedlings in which a number of linked genes segregated, estimates of linkage intensities and the apparent gene order were: glossy foliage (gl^b) with pale-green foliage (pg), 30.8 ± 6.9%; pg with po, 23.2 ± 6.3%; po with leaf excrescence (le), 14.8 ± 12.3% and le with hairy leaf margins (Hr-1), 27.2 ± 4.4%. The combinations gl^b with po, pg with le and po with Hr-1 also gave significant values. None of these was linked to Fern leaf (Fn) which also segregated. More seeds of this family will be sown to confirm these observations. Linkage between white petal (Wh) and fc was confirmed in four flowering families. Estimates of linkage intensity were 22.3 ± 0.1 in a backcross and 24.9 ± 5.8 in an F_2.

Experiments were started to define the methods by which pollen could be incubated in a liquid medium and subsequently used for effective pollinations. The ability of pollen to germinate on stigmas after recovery from a defined medium containing polyethylene glycol was shown to depend on the length of the incubation period and moisture conditions after recovery. The number of pollen tubes per stigma produced by treated pollen in the most successful experiment fell from 20 after 0.5 h incubation to almost nil after 4 h.

Genetic studies have been extended to the forage *Brassica* species. A number of *B. campestris* accessions were sown and analysed for acid

phosphatase isoenzymes (see project 03013) and are being observed for phenotypic variations.

(A. B. Wills, P. Smith, T. Hodgkin)

03019 *Breed calabrese cultivars adapted to north European conditions*

Seeds of two populations produced by random-mating of individuals selected for spear quality, yield and period of maturity (Ann. Rep. 1980, p.65), were bulked separately, sown in May and the resultant plants flowered in pots in a glasshouse. Plants with obvious defects were eliminated and about 120 were selfed and also crossed with the tester hybrid cultivars Corvet and Bravo to produce seeds for a further cycle of selection. About 80% of the flowering stalk was removed on each plant before it elongated. This treatment and heavy fertiliser application appreciably increased the size of the remaining buds, which greatly facilitated bud pollination and gave improved seed set and development.

Plants grown in 1980 from seed produced by random intercrossing of F_2 broccoli x calabrese plants selected for winter survival, biennial habit, head quality and plant morphology, headed in February and March. Many produced high quality calabrese-like heads, up to 200 mm in diameter, and selected plants were taken into a glasshouse for mass pollination by blowflies. The resulting F_3 seed was sown in July. No plants had flowered by the end of December, but, owing to poor growth, they entered the winter considerably smaller than did their parents in 1980.

Calabrese x curly kale hybrids, which were all annual flowering at the F_1 stage, were selfed and the progeny sown in July. Some plants flowered in the autumn and considerable variation in leaf type and coloration was apparent.

(A. J. Redfern, A. B. Wills)

NEW RASPBERRY CULTIVAR GLEN MOY

The Institute and the NSDO have applied for Plant Breeders' Rights for a new raspberry cultivar Glen Moy bred at SCRI.

Stocks are being propagated by the Nuclear Stock Associations and limited supplies will be available for commercial planting in winter 1982-83.

Breeder's number: 7210/204.

Origin	Glen Moy was raised from a cross made in 1972 between SCRI hybrids whose parentage includes *Rubus occidentalis*, Glen Clova, Lloyd George and Malling Landmark.
New canes	Stems are spinefree and pubescent. Secondary buds are frequent. Dormant canes are grey brown.
Vigour	Canes are numerous and vigorous.

Fruiting laterals	Medium long and strong. Frequently two or more present at each cane node.
Fruit	Large, short conical, light to medium red and moderately firm. Easy fruit abscission and good flavour.
Season of ripening	Glen Moy is early, similar to Glen Clova.
Diseases	This cultivar has gene A_1 for resistence to *Amphorophora idaei*, the main aphid vector of virus diseases. Glen Moy reacts to infection with leaf spot virus but not to infection with leaf mottle virus. It is immune from the Scottish strain of bushy dwarf virus. Tests for susceptibility to other viruses are incomplete. This cultivar shows extensive cane splits in spring and is therefore liable to attach by cane midge *(Resseliella theobaldi)*.
Hardiness	Glen Moy is less hardy than Glen Prosen but neither cultivar is hardy in all situations.
Identification	This is one of the first raspberry cultivars to be completely spinefree and Glen Moy can be distinguished from Glen Prosen by its pubescent canes.

NEW RASPBERRY CULTIVAR GLEN PROSEN

The Institute and the NSDO have applied for Plant Breeders' Rights for a new raspberry cultivar, Glen Prosen, bred at SCRI.

Stocks are being propagated by the Nuclear Stock Associations and limited supplies will be available for commercial planting in winter 1982-83.

Breeder's number: 6820/54.

Origin	Glen Prosen was raised from a cross made in 1968 between SCRI hybrids whose parentage includes *R. occidentalis*, Malling Jewel, Burnetholm, Lloyd George and Malling Landmark.
New canes	Stems are spinefree and are sub-glabrous. Secondary buds are rare. Dormant canes are medium brown.
Vigour	Canes are moderate in number and vigour.
Fruiting laterals	Medium long and strong. Usually born singly.
Fruit	Medium large, short conical to round, medium red and exceptionally firm. Easy fruit abscission and good flavour.
Season of ripening	Glen Prosen is mid season, similar to Malling Admiral.

Diseases This cultivar has gene A_1 for resistance to *Amphorophora idaei*, the main aphid vector of virus diseases. Glen Prosen does not react to infection with leaf spot virus or leaf mottle virus. It is susceptible to bushy dwarf virus. Tests for susceptibility to other viruses are incomplete. This cultivar shows extensive cane splits in spring and is therefore liable to attack by cane midge *(Resseliella theobaldi)*.

Hardiness Glen Prosen is hardy in most situations.

Identification This is one of the first raspberry cultivars to be completely spinefree and Glen Prosen can be distinguished from Glen Moy by its sub-glabrous canes.

MYCOLOGY

R. A. FOX

Selective or semi-selective media commonly contain as suppressants fungicides, antibiotics, toxic dyes and growth retardants. The use of colour is an unusual aid, but a long-known colour reaction between two species of *Phoma* has proved a sensitive and time-saving aid for locating and enumerating the potato gangerene fungus, *Phoma exigua* var. *foveata* in heavily contaminated cultures (p.76). This simple procedure and simple result stands in marked contrast to that from another investigation. Antibiotics are invariably used to suppress unwanted bacteria in fungal selective media but the report on chocolate spot of bean (p. 78) highlights a point too often ignored in endeavours to pinpoint by isolation a single pathogen or to confirm Koch's postulates; that is that 'typical' symptom development may not necessarily have a single cause. The analysis of pectic enzyme components from expanding chocolate spot lesions, coupled with the use of antibiotics applied to the host plant during symptom development, have revealed that the chocolate spot, long attributed to a single fungus *Botrytis fabae*, is the result of the co-action of that fungus and pectic enzyme producing bacteria. This result should stimulate re-examination of a number of diseases involving sudden aggressive phases of lesion development.

Many of the problems created by the intractable red core root disease of strawberry *(Phytophthora fragariae)* may rapidly recede. A highly sensitive root tip detection technique described in previous Reports is undoubtedly leading to cleaner certified planting stocks, which, together with carefully formulated chemical control techniques should relieve this long standing problem in many situations.

The preliminary results of applying copper sprays to potato plants raised from surface sterilized true seed suggest that it may not be difficult to improve the bacterial status of VTSC potato stocks at least in their early stages of multiplication. The results also suggest that selective and enrichment techniques for detecting *Erwinia* spp. may not be as sensitive as had been thought and may raise doubts as to the validity of assertions about the extent to which any given potato stock is free of these bacteria and of the assumed levels of their detectability in soils and other potential sources.

02017 *Biology of Potato Gangerene*

Effect of different soil environments on expression of tuber disease

Field experiments designed to examine the effect of various harvest and storage practices on the development of gangrene, show that the lowest overall disease levels are usually coincident with wet harvest seasons when tubers are lifted with soil adherent to their surface. Some of the many factors that could contribute to this generalised observation were examined in a glasshouse experiment using root temperature regimes of 15°C and ambient, and watering regimes of wet — frequent watering to saturation, or dry — water applied only when plants wilted. Tubers with gangrene lesions were planted in a 1:1 mixture of field soil: Universal Compost in 30 cm pots and the watering regimes imposed 2 months later at the time of tuber initiation. At each of three harvest dates, 27 August, 16 September, and 22 October, progeny tubers were counted and weighed and one sub-sample was tested for tissue susceptibility using dilute mycelial homogenate in 6 mm stab wounds. A second sub-sample was used both for assessing levels of tuber surface contamination by *Phoma exigua* var. *foveata* and for 'gangrene potential' by a standard wound treatment. Samples of roots, stolons and underground stems from each plant were surface-sterilised and cultured on agar to detect any treatment effects on their fungal flora.

Tubers were more numerous and larger following the wet than the dry regime. After the first harvest, *P. exigua* var. *foveata* was detected on 5.7 and 3.6% of the tubers from the wet and dry treatments respectively and 23.1 and 6.7% respectively developed rots following wounding. The pathogen was not detected on periderm discs prepared from the other two harvests samples and rots developed only in tubers from the wet treatment the incidence being 11.1 and 3.97% for the second and third harvest respectively. The mother tubers from all treatments mostly remained intact and even in late October the original gangrene rots were usually still identifiable as hard corky masses of tissue.

The overall results, which were not affected by the two temperature regimes, suggest that tubers from moist soils are more, rather than less likely to develop gangrene particularly if harvested early. The tissue susceptibility tests showed only that susceptibility decreased with delay in harvest, as occurs in the field, the wet and dry treatments having no significant effect on lesion size. The conflict between field and glasshouse results highlights the problems that may ensue in attempting to extrapolate results obtained from one environment to those that may be found in another, especially from root environments. For example, many glasshouse-grown tubers developed rots in storage caused by *Botrytis cinerea*, a phenomenon very rarely observed in field-grown tubers. Cultured periderm samples, especially from the dry treatments, showed much higher levels than found on field-grown tubers of

B. cinerea, *Trichoderma* spp. mucoraceous and other fast growing fungi, all known to inhibit growth of the gangrene pathogen. Moreover, whereas in the field the decaying mother tuber is well mixed with the progeny tubers by the harvesting processes thereby promoting spread of inoculum, in the glasshouse experiment the mother tuber was removed immediately to minimise release of inocula that might mask the treatment or harvest effects.

The commonest species detected in culture from root, stolon and stem base pieces was *Colletotrichum coccodes;* it was present in nearly all samples from all harvests and, as the season progressed, became increasingly dominant almost to the exclusion of other species. Samples from the dry soil environment generally had higher levels of *Rhizoctonia solani*, *Cylindrocarpon radicocola* and *Rhizopus* spp. than did those from the wet environment. The absence of notable differences in the flora from root, stolon, or stem pieces may simply have been the results of the overriding dominance of *C. coccodes*.

(R. A. Fox, E. Patricia Dashwood)

Cryptic lesions in leaves

Leaf samples were taken from plants of cv. Pentland Crown, grown in the field from either healthy seed tubers or tubers inoculated with *P. exigua* var. *foveata*, in July, August, September and October. Following surface sterilization and plating on agar, cryptic infection by *P. exigua* var. *foveata* was detected only in a few leaves in the July sample but in *ca.* 20% of samples taken at the three later dates there being rather more in leaves from plants grown from inoculated than from healthy tubers. The technique used also detected *Botrytis cinerea in ca.* 20% of the leaves.

(H. M. Wilson)

An improved technique for detecting Phoma exigua *var.* foveata

The observation of characteristic yellow-green crystals produced by *P. exigua* var. *foveata* when growing in nutrient-rich media is widely used to identify and detect this pathogen in cultured samples of tubers, plant tissues and soil. Semi-selective media incorporating fungicides and antibiotics to suppress fast growing antagonists have not proved very successful because of the sensitivity of the pathogen to potentially selective compounds and the readiness with which its growth and crystal production is suppressed by even limited growth of other organisms. Attempts to detect or enumerate low populations of the pathogen require considerable sample dilution and replication and the technique is disproportionately expensive in time and materials for the consistency and accuracy of the results obtained.

When *P. exigua* var. *foveata* is grown in dual culture with *P. exigua* var. *exigua* antagonism is evidenced by the formation of a purple line where the cultures meet. In soil dilution and other sample plates, traces of purple may sometimes be seen where no yellow-green crystals can be detected but

subsequent careful sub-culturing has confirmed the presence of the var. *foveata*. Various techniques have been used to seed before use plates of semi-selective media with *P. exigua* var. *exigua*. Detection of the var. *foveata* on periderm disks by the purple lines so generated was *ca.* 65% compared with *ca.* 15% using crystal detection. Moreover, purple line formation is usually visible within 1 week whereas at least 2 weeks are required to ensure detection by crystal formation.

(E. Patricia Dashwood, R. A. Fox)

02024 *Autecology of the strawberry red core fungus*

Oospore germination

The effects on germination of oospores of their age, of surface sterilising technique, substrate, temperature, pH and fungicides were examind.

When a mixture of antibiotics and fungicides replaced mercuric chloride in the procedure for cleaning oospores contamination increased four-fold, but there were no differences between either numbers of oospores that became active, i.e. entered the germination process, or in the number of active spores that produced germ tubes.

Oospores of two single-zoospore isolates were extracted from infected root systems at various times after inoculation to study the effect of age on germination. Germination of oospores of isolate 171, when extracted from roots 4-5 weeks after inoculation, was 50-65% on three separate occasions, but it fell steadily with increasing time after inoculation and was only 30-40% after 12 weeks. In contrast germination of isolate 168 was never more than 14% and did not change with time.

The optimum temperature for germination of oospores of isolate 171 was 15°C, 56% of the spores were active after 10 days. At −1°C no activity was observed but at 3°C some spores slowly became active. When the spores at these last two temperatures were transferred to 15°C after 2 and 4 weeks, activity and germination was comparable to that at 15°C in 3-4 days. Fewer spores germinated at temperatures above 15°C, and at 20, 25 and 30°C, 40, 3 and 0% respectively had germinated after 10 days. When transferred from these higher temperatures to 15°C after 2 or 4 weeks more germinated, but germination took longer than for those held continuously at 15°C and those from the highest temperature took longest.

Full strength McIlvaine phosphate/citrate buffer adversely affected germination, whereas 1/20 concentration satisfactorily controlled pH and did not influence germination. The effect of pH on oospore germination was examined on agars incorporating 1/20 strength buffer. Agars with pH values ranging from 3.9 to 7.9 were prepared. At pH 3.9 there were fewer active spores and none formed germ tubes. Between pH 4.5 and 7.9 the number of active spores was comparable to those on distilled water agar (DWA) controls, although at the lowest and highest pH fewer spores formed germ tubes.

When the fungicide aluminium tris (ethyl phosphonate) was added to DWA at 100 μg/ml it slowed the development of active spores and reduced the number forming germ tubes. However it also reduced the pH of agar from 6.5 to 4.3. When the fungicide was incorporated into buffered agars at pH 6.5 no effect on the fungus was observed and part of its activity in DWA appeared to be due to the change in pH.

The fungicide metalaxyl completely suppressed the formation of germ tubes by active spores at concentrations >1.0 μg/ml in DWA. It slowed the development of active spores at concentrations as low as 0.1 μg/ml, although the percentage germination on concentrations of the fungicide ranging from 0.1 to 30 μg/ml was eventually similar to that on DWA.

Oospore formation

Attempts were made to induce oospore formation by the fungus on laboratory media formulated to simulate host sieve tube contents. Various combinations of root extracts, prepared fresh, autoclaved, and by organic solvent extraction, and media containing combinations of carbohydrates commonly found in phloem were tried without success.

Oospore survival

Ooospores of *P. cactorum*, *P. megasperma* and *P. fragariae* were injected into small packets made of monofilament nylon cloth (20 μm mesh) which were buried in samples of a soil from the site of a severe red core outbreak. The moisture content of the samples was adjusted to 33, 67, 100 and 133% of the soil's moisture holding capacity (MHC) and stored at 5, 15, and 25°C. Packets were recovered at intervals and the proportion of viable and dead spores determined by microscopy. In addition, germination tests were performed with some spores after gentle washing and isolations were made from those that had been colonised by other microorganisms. The extent of colonisation within or on the oospores and the organisms depended on the species. The greatest numbers and diversity were associated with *P. megasperma* and the least with *P. cactorum*. Overall, actinomycetes and filamentous fungi were most frequent in dry soil and bacteria predominated in wet conditions; their common occurrence on dead spores suggested that they were hyperparasites which could be components of a natural biological equilibrium.

(J. M. Duncan)

02013 *Biology of root diseases in field peas and beans*

Biology of Botrytis fabae *in bean*

Elution from Sephadex G75 of a heat-stable phytotoxic fraction from field bean leaves infected with *B. fabae* indicated that the molecular weights of the active compounds were between 10,000 and 30,000 daltons. Further purification of the toxins was achieved by eluting them from DEAE Sephadex with 0.1 to 0.2 M NaCl solution.

Bacterial growth during the development of chocolate spot lesions was controlled with antibiotics. Extracts from these lesions contained large amounts of polygalacturonase (PG) but polygalacturonic acid trans-eliminase (PATE) and pectin methyl trans-eliminase (PMTE) could not be detected. PG was produced by *B. fabae* in liquid culture but PATE was absent, and there were only small amounts of PMTE. In the absence of antibiotics, however, there was a high level of PATE, but not of PMTE activity in lesion extracts. Antibiotics reduced the rate of increase in lesion diameter by 46%, while they reduced the rate of growth on agar of *B. fabae* by only 9%. These results suggest that PG produced by *B. fabae*, and PATE produced by contaminating bacteria, may play a role in the development of chocolate spot lesions. The importance of enzymes is supported by an observed decrease in phytotoxicity after autoclaving the precipitate formed when $(NH_4)_2 SO_4$ was added to a lesion extract.

Dehydrogenase activity during storage of conidia of *B. fabae* was determined by incubating spores in a solution of triphenyl tetrazolium chloride, dissolving the formazan in methanol and measuring its optical density at 480 nm. Loss of material from stored spores on immersion in water was determined by measuring the optical density at 254 nm of the soak water. ATP was measured with a luminometer after adding an extract in EDTA-buffer solution from spores to a solution containing luciferin, luciferase and magnesium ions. Loss of infectivity and viability preceded decreases in dehydrogenase and ATP levels and an increase in the loss of u.v.-absorbing compounds on soaking spores in water, indicating that the observed changes in these parameters may be symptoms rather than causes of death of conidia.

Conidia were kept out of doors on cobwebs during summer. Infectivity had fallen by 85% after 10 days, suggesting that many spores may remain infective after being carried by the wind over long distances.

In a field experiment, plants of four bean cultivars, sown during April, were sprayed to run off with 0.15% chlorothalonil every 2 weeks on five occasions during the summer. Foliar disease was assessed visually on 27 July and 18 August but there was little disease even in unsprayed control plots. Plants were harvested in September when most of the leaves had fallen off. Spraying with fungicide had no effect on the yield of oven-dry seeds of any cultivar, perhaps reflecting the exceptionally low disease levels observed in local bean crops during 1981.

Leaves were removed from benomyl-treated field plots near Cambridge in July 1981. Pieces of leaf bearing a chocolate spot lesion were plated on Last & Hamley's medium X agar, containing 10% sucrose to encourage sporulation, and 1000 ppm benomyl. *B. cinerea* grew from most leaf pieces but *B. fabae* did not grow from any, suggesting that benomyl-tolerant strains

of *B. cinerea* may be widespread and causally related to chocolate spot lesions.

(J. G. Harrison)

02010 *Seed quality — soil interactions and their effects on seedling growth*

Barley seedling emergence

Barley, cv. Golden Promise, was stored at high m.c. (20%) and temperature (30°C). Samples of increasing levels of deterioration were obtained by withdrawing lots at regular intervals and drying to 10% m.c. Four seed lots were treated with 1) 25% w/w calcium peroxide (Laporte Industries Ltd.) as a slurry, 2) 0.2% w/w phenyl mercury acetate dust (Murganic RPB, Murphy Chemicals Co.), 3) 0.15% w/w triadimenol + fuberidazole dust (Baytan, Bayer UK Ltd.) and sown in the field in single row plots on 30 March. Four replicate plots were grown each split for normal seed bed conditions and for beds kept permanently at field capacity by a trickle irrigation system. Sand-maize meal cultures of *Fusarium culmorum* and *F. nivale* were placed in some rows alongside the seeds.

The fungal inocula had no effect on percentage emergence or seedling growth in either seed bed conditions although *F. nivale* was readily isolated from the hypocotyl region. *F. culmorum* was less frequently isolated. In the normal seed bed, emergence was closely correlated with the viability of the seed lots which were all >90% and was not affected by fungicide or peroxide treatments. In contrast, mean emergence was halved in the wet seed beds and the deteriorated lots were affected more than the non-deteriorated lots. Emergence in the wet beds was not improved by the fungicide seed treatments but it was increased by calcium peroxide from a mean of 39.7 to 53.9% (SED = 4.62). The results of a second experiment sown on 28 April confirmed the beneficial effects of calcium peroxide seed treatment on seven seed lots sown in wet soil conditions and the improvement was greatest for the most deteriorated seed lot. Calcium peroxide releases molecular oxygen in contact with wet soil and the results of these experiments confirm the hypothesis formulated previously (Ann. Rep. 1976, p.69) that death of barley seed in wet soil is caused by anoxia.

Pathogenicity of Fusarium nivale

F. nivale was frequently isolated from the roots and hypocotyls of barley seedlings grown from naturally contaminated seed harvested in 1980 and seed treatment with triadimenol + fuberidazole dust (Baytan) and phenyl mercury acetate dust (Murganic RPB) did not alter its incidence. It was isolated more frequently from seedlings grown in controlled conditions from both infected seeds and seeds exposed to sand-maize meal inoculum at 10°C than at higher temperatures and in sand and peat compost compared with autoclaved soil. Substrate moisture content had no effect.

(D. A. Perry)

02026 *The nature and implications of quiescent fungal and bacterial infections*

A method has been developed for separating and measuring potato phytoalexins by HPLC. Rishitin, phytuberin, solavetivone (katahdinone), lubimin, 10-epilubimin, 15-dihydrolubimin, and 3-hydroxylubimin are separated on a 5μm Ultrasphere silica column (4.6 x 250 mm) using a gradient from 3 to 25% isopropanol in hexane over 20 min, and measured using a u.v. detector at 210 nm. This method has a greater resolving power than reverse-phase HPLC, is faster than published techniques using GLC, and requires no partial purification of extracts by TLC. This technique is now being used to measure the phytoalexins in rots of individual tubers inoculated at different temperatures with several isolates of either *Erwinia carotovora* sub sp carotovora, *E. carotovora* sub sp *atroseptica*, or *E. chrysanthemi*. Replicate potato rots are being analysed for the presence of polygalacturonase and PG lyase. There is evidence (Ann. Rep. 1980, p.76) to suggest that a pectic enzyme from sub sp *carotovora* can act as a phytoalexin elicitor. These experiments will therefore also provide evidence on whether the spectrum of pectic enzymes that an isolate can produce *in vivo* can affect the range and final concentration of phytoalexins accumulating in the potato.

The sensitivity of sub sp *atroseptica* to the phytoalexin rishitin can be altered by changes in composition of the nutrient medium *in vitro*. Experiments have been started to study in detail the interaction of rishitin with a number of nutrients and cations which are present in potato tubers. Changes in respiration rate of sub sp *atroseptica* after the addition of rishitin to a defined liquid medium can be continuously monitored over 30 min using an oxygen electrode. The readings allow a more detailed analysis of the data than could be achieved by, for example, measuring the number of viable cells at a relatively few time intervals, and the small sample volume (1 ml) minimises the quantities of rishitin required. At the end of the 30 min assay period, numbers of viable cells were also counted to confirm the relationship between respiration rate and viability. This work should further improve the prospects of breeding potatoes resistant to *Erwinia* spp by providing breeders with information on potential tuber composition which will enhance phytoalexin activity against the pathogen.

(G. D. Lyon)

02015 *Disorders of vegetables*

Cavity spot of carrots

Carrots cv. Red-cored Chantenay were grown at a site on the Panbride Raised Beach soil series. Linuron and phorate granules were applied at recommended rates for weed and insect control, respectively. Seeds were

sown with a Stanhay drill, fitted with a three-row belt and scatter band coulter calibrated to deliver 215 seeds/m row, in single rows 0.7 m apart and 20 m long, in two row plots. On 27 April seeds were sown either on top of ridges made with a potato ridging plough or on the flat. Immediately after sowing, the rows on the flat were either rolled or cultivated with tractor-mounted grubber times which penetrated *ca.* 100 mm deep, *ca.* 100 mm on either side of the rows; the three cultivation treatments were replicated five times. The ridges were re-made on 9 July and the tines were passed through the previously cultivated plots on 9 July and 14 August. Roots were harvested on 1 October and 3 November by hand, topped, size graded, washed and examined for cavity spot symptoms.

There were no significant differences in the number or weight of roots from each treatment at either harvest. At the second harvest, the incidence of moderate and severe lesions in the canning-size grade was reduced from 13.9% in the flat rolled plots to 3.4 and 6.6% in the flat cultivated and ridged plots respectively (SED = 1.99). Similar significant trends were recorded in the slight lesion category and at the first harvest. The results confirmed those obtained in 1980 (Ann. Rep. 1980, pp.77-78) that cultivation to improve aeration along rows of carrots substantially reduced the incidence of cavity spot.

(D. A. Perry, T. G. Rubens[1])

Induction of carrot root lesions

Field soil from several sources was mixed with an equal volume of water and 1% glucose and incubated anaerobically for 7 days. Cotton wool swabs saturated with the supernatant applied to the surface of mature carrot roots for 48 h initially caused water-soaked areas which later collapsed to form sunken lesions. Filter-sterilised extracts of the supernatants caused lesions which were smaller than the non-sterile supernatant. A series of aliphatic acids were similarly applied to roots and formic acid at a concentration of 50 mM induced large lesions and smaller lesions at 10 mM, while acetic, propionic, butyric and valeric acids were less toxic at 50 mM and non-toxic at lower concentrations. There was no evidence of synergism when the acids were applied in mixtures. A range of aromatic acid was also tested and salicyclic acid was strongly toxic at 10mM, less so at 2 mM and non-toxic when applied at similar concentrations as the sodium salt. Benzoic, hydrobenzoic, coumaric, phenylacetic and vanillic acids were all capable of inducing lesions at 10 mM but not at 2 mM. A cell-free pectic enzyme solution prepared by sterile filtration of a culture of a pectolytic *Clostridium* sp on liquid polypectate also caused a collapse of the secondary phloem when applied in cotton wool swabs. These experiments show that the carrot periderm is readily penetrated by a range of toxic substances which cause a

[1] East of Scotland College of Agriculture.

collapse of the secondary phloem tissue characteristic of cavity spot symptoms.

(D. A. Perry)

02018 *Diseases of potato tubers*

Tuber infection by E. carotovora: *cultivar relative susceptibility*

Thirty cultivars selected for known variation in field susceptibility to blackleg were grown in a field at SCRI and stored at 5°C after harvest in October. Tubers were sampled before and after harvest from August 1980 to May 1981 and their relative susceptibility/resistance to decay was determined by a infectivity-titration procedure using graded concentrations of a strain of *Erwinia carotovora* sub sp *atroseptica* and the tubers incubating for 5 days in a 10% 0_2, 90% N gas mixture flowing at 0.2 l/min at 22°C. The results were expressed as the ED50 of bacterial numbers required for induction of visible decay. The susceptibility of most cultivars was greatest in mid October just after harvest and it tended to decline gradually to a minimum in March. Most of the cultivars maintained their susceptibility ranking throughout. Among the susceptible cultivars were King Edward, Maris Piper, Pentland Crown, Pentland Javelin, Pentland Hawk, Maris Bard with ED50s of *ca.* 10^1 cells in October rising to 10^4 cells in March, while Cara, Golden Wonder, Ulster Sceptre, Vanessa, Wilja, Arran Pilot with ED50s of *ca.* 10^3 cells in October and *ca.* 10^6 cells in March were resistant. However, a few cultivars showed variable behaviour during the sampling period, e.g. the reactions of Record placed it in the susceptible category in October but among the resistant cultivars in March while Pentland Squire and Red Skin exhibited a reverse trend. Although tuber tissue water deficit measured by psychometry increased gradually during the sampling period, it was not always associated with susceptibility to decay.

Susceptibility of tubers of Pentland Crown was correlated with an increase in temperature and a reduction in 0_2 concentration.

(R. Lowe, M. C. M. Pérombelon)

02027 *Studies of plant pathogens*

Survival of E. carotovora *in soil and water*

The presence of *Erwinia carotovora* sub sp *carotovora (Ecc) and E. carotovora* sub sp *atroseptica* (Eca) in soil at a depth of *ca* 10 cm in the rhizosphere of weeds and crops was monitored at monthly intervals in fields with different cropping histories at the SCRI and on two commercial farms in Perthshire where VTSC and FS seed potato grades are produced. The numbers of the bacteria in soil and rhizosphere were low and a sensitive enrichment technique was used which detected <10 cells/g soil. *Erwinia* was not detected in fields in the absence of potatoes until September on one farm and until October on the SCRI and the other commercial farm. They were found in more than 45% of the soil samples from each farm, a month later

but their occurrence subsequently decreased and the cropping history of the fields had no apparent influence on their survival. Fields on which potatoes were grown in 1980 remained contaminated through the winter but the bacteria were not detected in the spring and summer. Although the bacteria were more frequently detected in the rhizospheres of weeds and crops than in soil, survival was not favoured by any particular weed species including potato groundkeepers. These results confirmed the findings of previous small scale surveys (Ann. Rep. 1980, pp.78-79) although, in contrast, Ecc and Eca were present in equal numbers.

The Alyth Burn and its main tributary streams in Perthshire were sampled at 20 points from the source to the confluence with the river Isla. The water samples were passed through membrane filters which were incubated on Crystal Violet Pectate medium to determine the numbers of erwinias present. Where the river flows through arable land the levels of contamination from May to December were always within the range of 10^2 to 10^3 erwinias/1; in the upper reaches where it flows mostly through grazing land the numbers fell to 10^1 to 10^2/1 but none was detected at sites near the source in moorland. Numbers were greatest in November but fell sharply afterwards. From flow rates provided by the River Tay Purification Board an estimated 10^{11} to 10^{12} cells of *Erwinia* flowed through the lower reaches of the river every 24 h. Although both Ecc and Eca were often jointly present, the former was four times as numerous as the latter.

The total numbers of bacteria in the river ranged between 10^4 and 10^5/ml at all sampling sites and throughout the sampling period.

Random samples of drain water from arable fields showed that there were usually *ca.* 10^2/1 erwinias present irrespective of the past cropping history. However, drain water from non-arable fields was only occasionally contaminated by the bacteria.

Preliminary results of the survival of soft rot erwinias in distilled sterile water showed that 30 strains of Ecc and Eca from different sources including river water survived better at pH 5.0 and at 15°C than at pH 7.0 and 5°C.

(M. C. Pérombelon, Lizbeth J. Hyman)

Pectic enzyme production by Erwinia carotovora

The viscometry method for determining polygalacturonase (PG) activity was modified by using 0.1 M sodium acetate-acetic acid buffer instead of Sorensen's citrate-HCl buffer and hydrolysis was arrested by adding 0.1 ml 5N NaOH instead of boiling. The optimum pH for PG activity was 4.9 and it was inactivated at pH <3.0 and >6.5.

Production of polygalacturonic acid transeliminase (PATE) and PG by several strains of Ecc and Eca at different temperatures in liquid media with and without pectate under aerobic conditions was reported previously (Ann. Rep. 1979, p.74; 1980, p.81). Attempts to repeat this study under anaerobic conditions failed because the bacteria did not grow even in

nutrient-rich liquid media. Addition of bicarbonate to the media to negate any possibility of osmotic fragility caused by CO_2 deprivation, the inclusion of different C and N sources, and the use of cell free sonicates of the bacteria were all unsuccessful. However, growth reached $5x10^8$ cells/ml in 24 h at 27°C when the media were supplemented with the reducing agents cysteine hydrochloride (100 μg/ml) and dithiothreitol (5 mM).

(R. Lowe, M. C. M. Pérombelon)

Genetics of E. carotovora

Several *Erwinia* species contain indigenous plasmids which in *E. carotovora* may interfere in the acquisition and expression of sex factors F and R of the P1 incompatibility group. A transfer frequency of RP4 from *E. coli* of $<10^{-8}$ per donor cell was shown in 80% of the 28 strains of Ecc and Eca (Ann. Rep. 1979, p.75) and the few physiological properties which differentiate Ecc from Eca and the characters which control virulence and host range could be plasmid borne as has been suggested in other erwinias. To test this hypothesis, 35 and 25 strains of Ecc and Eca respectively were screened for the presence of plasmids by Eckhart's agarose gel electrophoresis method. Only 12 strains of Ecc contained plasmids, nine of them had small plasmids (<10 M dal), three had large (25-180 M dal) and six had more than one plasmid (small or large) per cell. Of eight strains of Eca shown to contain plasmids five and six had small and large plasmids respectively and seven contained more than one plasmid. The plasmids were not associated with antibiotic resistance, bacteriocin production, efficiency of transfer of sex factors by bacterial conjugation, or with pathogenicity. Moreover, the different properties of Ecc and Eca could not be explained in terms of plasmids.

(M. C. M. Pérombelon, Lizbeth J. Hyman)

Characterisation of pectolytic Clostridium *spp.*

Continued studies on 56 isolates of pectolytic *Clostridium* spp. isolated from soil and rhizospheres of carrots showed that growth and acid production on 16 different sugars varied between the isolates to such an extent that most of them could not be assigned to described species. Cluster analysis of the data revealed the existence of three groups of broadly similar properties and a number of isolates which were dissimilar from each other.

(D. A. Perry)

EPIDEMIOLOGY AND ETIOLOGY

02003 *Shoot disorders of cane and bush fruits*

Cane diseases of raspberry

Cane blight

A new fruit catching system developed at the Scottish Institute of Agricultural Engineering (SIAE) for the SIAE raspberry harvester test rig

was designed to minimise the wounding of young canes and the risk of infection by *Leptosphaeria coniothyrium*. The system makes no contact with young canes except for a rubber belt on each side of the raspberry row which moves backwards at a speed identical to the forward speed of the rig (Ann. Rep. 1980, p.80). The benefit of the new catching system relative to that of the Littau harvester was evaluated by inoculating young canes of the cultivars Glen Clova, Glen Isla, Malling Jewel and Malling M with mycelium and pycnospores of *L. coniothyrium*, isolate 902 (IMI 190198) in plots harvested once by either machine on 16, 22 and 28 July 1980; to ensure that the inoculum was effective in the field, scalpel wounds were also inoculated. All inoculations and non-inoculated controls were permanetly covered by self adhesive bandage.

Infection at the catching area of canes was 77% in the Littau harvested plots and 42% in plots harvested with the SIAE rig and in the non-inoculated controls. Girdling of canes by vascular lesions was 2.95 for Littau and 0.77 (score scale 0-4, where 4 is girdled) for the SIAE rig, a value that would be unlikely to reduce yield (Ann. Rep. 1979, pp.75-76). The components of yield for treated canes above the catching zone where the rig was used was 11 laterals with 102 fruits plus flowers, compared with five laterals with 43 fruits plus flowers per cane in the Littau harvested plots.

The experiment was considered to be a particularly severe test of the two catching systems because mycelial inoculation in July usually kills canes wounded by scalpel. Natural infection, assessed by infection of the non-inoculated scalpel wounds, was unusually heavy in this plantation in 1980 and covering harvester wounds immediately after a harvest may encourage infection. Nevertheless, under these test conditions the belts of the SIAE test rig were shown to be a substantial improvement over the metal spring-loaded catching plates of the Littau harvester in predisposing canes to blight.

(B. Williamson)

Raspberry yellow rust

Phragmidium rubi-idaei, an autoecious leaf and cane rust of raspberry, has been reported from wherever the crop is grown, but rarely has the disease been important in the UK. Raspberry yellow rust has now become prevalent on some newer cultivars, notably Glen Clova and Malling Delight in certain localities throughout the UK.

There is little information on resistance of red raspberry to *P. rubi-idaei* but the cultivars Latham and Chief have been reported to be highly resistant to N. American strains. Seven cultivars, arranged in a randomised block design, were exposed as young bait plants in a rust-infected Glen Clova plantation in Grampian Region on 23 June to identify possible sources of resistance. All leaves of cultivars Malling Delight, Glen Clova and Malling Jewel, 82% of those on Meeker, but none of Latham, Chief and Boyne were infected when sampled in October. Of the infected cultivars, the leaves of

Glen Clova and Malling Delight were most severely affected with 15.0 and 19.1 teliosori per cm^2 respectively, values significantly higher than Malling Jewel (2.9) or Meeker (0.6).

Rust also occurred in a trial to compare advanced selections and cultivars from the United Kingdom *Rubus* breeding programmes, planted by the East of Scotland College of Agriculture in Perth and Kinross District. The replicated trial was set out within an established plantation of Glen Clova which developed a moderate rust attack for the first time in 1981. When the trial plots were sampled on 22 October, 100% of leaves sampled from the young canes of 2476/46, 1318/27, Glen Clova, Glen Moy and Joy were infected, an incidence not significantly different from Malling Jewel selected as the standard for comparison (95%) or M30 (97%); Leo (61%;, Glen Prosen (33%), 6820/64 (47%) and 2488/36 (5%) had significantly fewer infected leaves than Malling Jewel.

The severity of infection, relative to Malling Jewel, was studied by assessing the cover of the abaxial leaf surface by teliosori on the scale 0 (no infection) to 4 (severe). Five selections ranked by mean disease indices were more severely infected than Malling Jewel (0.29), namely 2476/45 (1.42), 1318/27 (1.04), Glen Clova (0.99), Glen Moy (0.78) and Joy (0.76) but M30 (0.34) did not differ significantly; Leo (0.16), Glen Prosen (0.05), 6820/64 (0.05) and 2488/36 (0.00) were less severly infected.

(Vivienne M. Anthony, B. Williamson)

Spur blight

The effect on bud development of leaf loss or infection by *Didymella applanata* was studied on cultivars Malling Jewel and Glen Clova in the field. Leaves subtending the buds on the 12th, 15th or 18th nodes of young canes were inoculated with *D. applanata* at a wound in the petiole or had their leaflets removed on 2 July, 13 August or 8 September; healthy undamaged leaves were used as controls.

For both cultivars the primary axillary buds which subtended the leaves inoculated on 2 July were significantly shorter and a smaller proportion of them produced laterals than those from the untreated nodes. No such effects were detected for buds inoculated later. The primary buds at nodes where leaflets had been removed were as big as the controls, but in Glen Clova a small proportion of them produced laterals after the treatment on 2 July.

In a small experiment in an unheated glasshouse with 2-year-old plants of Malling Jewel, the petioles of leaves at the 12th node of young canes were inoculated with *D. applanata* or the leaflets removed on 2 July or 14 August. When assessed in March the axillary buds at the nodes of the inoculated leaves were significantly shorter than those at the untreated nodes and those at nodes where leaflets had been removed regardless of treatment date.

The field experiment suggested that *D. applanata* inhibited bud development and lateral shoot growth at the nodes it infected, but only if the subtending leaves were infected when they were expanding in early July.

Natural infections first occur on senescent leaves at the bases of canes. Infection on the leaves of nodes in the cropping region occur only at times when no effect on bud size was detected after inoculation with *D. applanata*. This result indicates that there may be only a brief period when natural infection of nodes with susceptible leaves can inhibit subsequent bud development in the cropping region of canes. The glasshouse experiment suggests that this period may be prolonged in warmer environments.

(B. Williamson, A. Dale[1])

Raspberry root disorders

In previous glasshouse experiments young raspberry plants of five cultivars growing in pots inoculated with the black root fungus *Thielaviopsis basicola* showed no differences in cane height compared to uninoculated controls despite the development of typical black root rot symptoms in one of the cultivars, Glen Clova, and continuing high populations of the fungus in the compost around the roots of all the cultivars. Because potential dwarfing effects on growth caused by root infection may have been masked by the restriction of root growth imposed by the pots, the plants were inoculated when between 20 and 30 cm high, and repotted into large pots after 6 weeks. Three cultivars were tested, Glen Clova, Malling Promise and Malling Jewel but again there were no significant differences in height between treated and control plants. The viability of the inoculum was tested at 4 and 6 weeks after inoculation by baiting samples of drainage water from the pots with sterile carrot discs and observing the proportion that developed typical black chlamydospores after 7/8 days incubation. At the first test all samples from all pots were positive but the highest numbers of positive discs came from pots containing plants of Glen Clova. In the second test only a quarter of the samples from Malling Promise and Malling Jewel were infected whereas 90% of those from Glen Clova were positive. The control samples remained negative from plants of Malling Promise and Malling Jewel in both tests, but some contamination of the Glen Clova controls was apparent, 1 of 3 and 4 of 10 of the drainage samples being positive at the first and second test respectively.

Root systems were sampled after 3, 5 or 8 weeks for disease symptoms and the associated compost was tested for the presence of *T. basicola* using carrot baits. Although the compost from all the inoculated pots was consistently positive in the bait tests, typical black rot symptoms developed only on roots of Glen Clova. Again, the control plants of this cultivar were infected, the level and symptom production being almost as high as that in the inoculated plants. The control plants of Malling Promise and Malling Jewel also showed some low levels of infection and although the controls were isolated from the inoculated plants this observation suggested cross

[1] Plant Breeding Section.

contamination between the controls, the plants of Glen Clova possibly being the source.

In consequence five root/compost samples were taken directly from the root systems of the primary raspberry mother plants of each of the three cultivars growing in the quarantine screen house and tested for *T. basicola* using carrot baits. At the same time 10 samples of fresh Universal Compost and autoclaved Universal Compost were baited to check for outside sources of contamination. The result from these checks were negative as they also were for the samples from the mother plants of Malling Promise and Malling Jewel. However, three of five of the Glen Clova mother plant compost samples were infected suggesting that plants derived from this source would also be infected.

(R. A. Fox, E. Patricia Dashwood)

02022 *Harvest disorders of soft fruit*

Effect of fungicide sprays on incidence of grey mould in raspberry fruit

Results obtained over four seasons established that the incidence of *Botrytis cinerea* on raspberry flowers and fruit increases steadily through the flowering and fruiting season and also increases on individual flowers and fruits as they mature. This season, starting at the end of June, plots of cv. Malling Jewel were successively sprayed with dichlofluanid at 5 to 6 day intervals, the first spray being applied between 2 and 20 days of petal opening. Flowers were individually tagged at the start of the programme and the fruit which subsequently developed was harvested at the end of July and tested for *B. cinerea* infection either by surface-sterilization followed by culture on agar media, or by inducing sporulation by storing fruit individually in damp chambers. A parallel spray programme was started in early July for flowers which opened later in the season and their fruit collected in early August.

The incidence of *B. cinerea* on fruit increased with delayed spray application from 18% for canes which had received seven successive sprays starting on 25 June, to 95% for canes which had been sprayed only twice, starting on 20 July. The incidence was higher in fruit developing from late-opening flowers increasing from *ca.* 50% when spraying was started on 2 July, to 95% when spraying started on 27 July. The incidence on unsprayed fruit was consistently 100%. These preliminary results indicate that if fungicides are to be effective, application should be at an early stage in the fruit development cycle when the fungus is presumably little more than a surface contaminant. Later sprays, however, may still have a beneficial effect in that they may control inoculum spread.

(R. A. Fox, E. Patricia Dashwood)

Red core of strawberry

Decreases in yield due to disease were examined in pairs of cultivars with the same susceptibility in three adjoining sites of infested and non-infested soil in the field. Degrees of susceptibility (as determined by tests in a controlled environment) were represented by the cultivars Cambridge Favourite and Redgauntlet (susceptible), Silver Jubilee and Tantallon (moderately susceptible), and Cambridge Vigour and Saladin (slightly susceptible). Six plots (24 plants/plot) of each cultivar were randomized in each of three Latin squares (= sites) and all plants in one of the two infested sites were root-soaked before planting and sprayed annually in the autumn with aluminium tris (ethyl phosphonate) (LS 74783). Mean yields from infested and non-infested sites in the first cropping year (1980) indicated that susceptible cultivars had responded similarly while moderately susceptible and slightly susceptible ones had responded differently to disease. All pairs differed in the second year but the differences in either year were not significant. The same comparisons made in relation to fruit size indicated that the susceptible cultivars differed most in the first year while the slightly susceptible ones were most dissimilar in the second year.

Mean yields from the fungicide-treated infested site and the non-infested site showed that differences were similar within all pairs in the first year and those which occurred in the second year were not significant. The biggest difference within pairs in relation to fruit size in the first year occurred in the susceptible category and the smallest in the slightly susceptible category. Although differences were less in all categories in the second year the trend was similar.

(Isabel G. Montgomerie, Diana M. Kennedy)

Verticillium wilt of strawberry

Breeder's selections 63AF85, 68WT17, 69DB54 and 69ET157 were screened in a glasshouse for susceptibility to a mixture of *V. dahliae* and *V. albo-atrum* and all were as susceptible as the standard susceptible cv. Cambridge Vigour.

(Diana M. Kennedy)

Verticillium wilt of raspberry

In a preliminary evaluation of methods for screening *Rubus* genotypes for susceptibility to *Verticillium*, red raspberry, black raspberry and a red and black raspberry cross were inoculated with a conidial suspension of *V. dahliae*. Wilt symptoms appeared on the canes and *V. dahliae* was subsequently re-isolated.

(Diana M. Kennedy)

Stamen blight of raspberry

The number of axillary buds of cultivars and *Rubus* spp. infected following hypodermic injection of spores of *Hapalosphaeria deformans* was lower than in 1980 and varied from 7-77%. A derivative of *Rubus strigosus* developed the lowest number (7%) of diseased inflorescences with only 6% diseased flowers/inflorescence, and the disease was obtained in the cv. Cuthbert for the first time.

The susceptibility of genotypes with different combinations of characters for hairy and spiny stems was evaluated by the above technique. Fewer axillary buds were infected and the number of diseased flowers/inflorescence was lower in genotypes with hairy, compared to glabrous, stems. There was no difference in the number of axillary buds infected in genotypes with and without spiny stems but the number of diseased flowers/inflorescence was higher in genotypes with spiny stems.

(Isabel G. Montgomerie, Diana M. Kennedy)

02019 *Gangrene, blackleg and soft rot and recontamination of VTSC seed potato stocks*

Blackleg etiology: field studies

The relative susceptibility of 12 cultivars was tested in replicated plots of 90 seed tubers inoculated with similar numbers of *Erwinia carotovora* sub sp. *atroseptica* (Eca). The average incidence of blackleg affected plants in late June following near average spring rainfall and temperature was 6.7%, but in early August, after prolonged periods of high soil water status during the first 3 weeks of July, it was 31.3%. There was little further disease development in August or in September which had more than twice the average rainfall. The 12 cultivars could be divided into four groups based on the percentage of diseased plants. Cultivars Pentland Squire, Croft, Pentland Crown were classed as resistant with 6.9 to 10.6% diseased plants; cultivars Desiree, Record, Maris Piper were intermediate (14.2 to 21.1%), cultivars Pentland Lustre, Estima, Pentland Hawk, Wilja, Maris Bard were susceptible (31.9 to 58.6%), and cv. Bintje was very susceptible with 74.2% affected plants.

The effect of chitting seed on blackleg development was examined in a field experiment in which seed lots of cultivars Bintje and Maris Piper were inoculated with low and high populations of Eca in November, 1979, stored over the winter at 5°C and *ca.* 6 weeks before planting in April were chitted in trays kept at *ca.* 15°C either in darkness or in the light in a glasshouse. The control consisted of seed kept at 5°C in store. There were no statistically significant treatment effects on blackleg incidence although there was a tendency for seed chitted in both environments to produce more diseased plants than the controls.

(M. C. M. Pérombelon, R. Lowe)

Contamination of crops by erwinias from different sources

Leaves of a 50 plant-plot grown from erwinia-free VTSC grade seed sited in the middle of a commercial ware potato field were lightly sprayed with a suspension containing 10^8 cells per ml of streptomycin resistant strains of *Erwinia carotovora* sub sp. *carotovora* (Ecc) and Eca in a 1:1 ratio in mid August. Although the bacteria could not be enumerated by the dilution plate technique after a week they were detected by an enrichment procedure more than 7 weeks later. When leaves and daughter tubers of neighbouring plants along a transect across the plots were tested 53 days after inoculation, the bacteria were detected up to 30 m distant. The ratios of streptomycin resistant Ecc and Eca cells on leaves and daughter tubers were 20:1 and 1:1 respectively.

In an attempt to determine the relative importance of the mother tuber and the phylloplane as potential sources of daughter tuber contamination, plants grown from seed heavily and lightly contaminated with Eca were sampled at different times during the growing season. By June or July the heavily contaminated mother tubers had decayed and the daughter tubers were extensively contaminated from then until harvest time. The lightly contaminated mother tubers rotted slowly and only *ca.* 50% were affected by late August. Leaf contamination was first detected in August on plants from all treatments and the bacteria were present in low numbers until harvest. Both Ecc and Eca were present in equal numbers on leaves, in contrast to previous years when Ecc predominated (Ann. Rep. 1979, p.52; 1980, p. 85), and both were present on the daughter tubers at every sampling time. The relative importance of mother tubers and the phylloplane as sources of contamination may be evaluated better by using marker strains as inoculum.

(M. C. M. Pérombelon, R. Lowe, Pirkko Harju[1])

Contamination of VTSC stocks by E. carotovora

The annual survey of VTSC stocks in the process of multiplication was continued on two commercial farms and 650 tubers from 18 stocks were examined. Tuber contamination of stocks in their first 2 multiplications years was *ca.* 60% on one farm and *ca.* 30% on the other, whereas in subsequent multiplication years it ranged from 85 to 100% on both farms. Moreover, contamination by Eca was nearly twice as high in stocks from the farm producing the more contaminated tubers. Differences in contamination levels occurred in 12 VTSC stocks in their 3rd and 4th multiplication years on a further six farms within a 50km radius. Contamination levels ranged from 36 to 96% in seven of the stocks from three farms and 0 to 10% in the remaining five stocks on the other farms.

(M. C. M. Pérombelon, Lizbeth J. Hyman)

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[1] Department of Plant Pathology, University of Helsinki, Finland.

Effect of foliar application of pesticides on crop contamination by erwinias

Potato plants were raised in the glasshouse from surface sterilized botanical seed obtained from open-pollinated plants of Maris Piper. They were transplanted to the field in May in four replicate plots each of 14 drills of 36 plants. Three sub-plots each of 24 plants in pairs of drills with 12 guard plants at their ends, were separated by pairs of guard drills within each plot and allocated at random to three treatments. Control sub-plots were left unsprayed and the other two sub-plots were sprayed twice weekly from July to October with either a copper fungicide (Cuprokylt, Universal Crop Protection Ltd) or an experimental bactericide (CGA 78039, Ciba-Geigy Ltd) at 5 g/l and 1.6 g/l respectively using 0.5 l per sub-plot. Late blight (*Phytophthora infestans*) was controlled by hand rogueing except for one application of captafol (Sanspor, ICI) applied in mid August. Plants were sampled in early and late September and in early October, the leaves tested for the presence of erwinias using several detection and enrichment procedures, and the tubers tested by a rotting procedure. The bacteria were detected on leaves only on the first sampling date from one sub-plot of the control plants (unsprayed) and with only one of the several techniques used. Of the total of 60 tubers sampled per treatment *Erwinia* contamination was detected in 28, 16 and 1 in the control, bactericide and copper treatments respectively, the sole contaminant in the copper treatment being detected on the last sampling date alone.

In the USA, analysis of soils from plots where potatoes had been sprayed with copper fungicides showed that the amount of 'water extractable' copper was *ca.* 7 ppm and the content of 'replaceable' copper ranged from *ca.* 20-90 ppm and that such ranges could variously affect the growth and germination of *P. infestans*. Preliminary *in vitro* tests, showed that the motility of *E. carotovora* sub sp. *atroseptica* was stopped at concentrations of ≤10 ppm Cu and that of *E. carotovora* sub sp. *carotovora* at levels of ≤5 ppm. Zinc and manganese are common components in complex late blight fungicides but when their sulphates were also tested, at rates up to the equivalent of 100 ppm Zn or Mn, neither sub-species was affected, instead, their motility, especially that of sub. sp. *carotovora*, was enhanced by Mn.

(R. A. Fox, E. Patricia Dashwood, Pirkko Harju, M. C. M. Pérombelon)

PLANT PROTECTION

02001 *Chemical and cultural control and economic importance of diseases of cane and bush fruits.*

Raspberry yellow rust reduced by vigour control techniques.

An outbreak of raspberry yellow rust *(Phragmidium rubi-idaei)* in Kincardineshire and Deeside District, Grampian Region was more serious

in part of a plantation of cv. Glen Clova where no sprays of dinoseb-in-oil had been applied than in those areas where sprays had been required each year to control cane vigour. Teliospores, the overwintering stage of this autoecious rust, were found on leaf litter or adhering to the canes, particularly in splits in the rind at the base of canes.

Two replicated trials were established to examine the possible interactions between vigour control and rust infection, one at the above site and the other in a rust-infected plantation of Malling Delight at Pen-y-ffridd Field Station, University College of North Wales, Bangor. Seven treatments were applied at both sites; two dinoseb treatments (10 l and 20 l/ha) used as pre-emergence herbicides; three vigour control treatments applied when the first flush of young canes were 10-20 cm high by cutting or by sprays of dinoseb at 10 or 20 l/ha and two untreated controls were included.

In the trial with Malling Delight at Pen-y-ffridd the three vigour control treatments reduced infection at the aecidial stage on the young replacement canes in early June from 33.8 aecidia per cane in the controls to 1.1, 0.2 and 0.5 aecidia per cane for dinoseb applied at 10 and 20 l/ha and the cutting treatment respectively. Pre-emergence dinoseb sprays at neither 10 nor 20 l/ha significantly reduced infection compared with the controls. Similarly in the Glen Clova trial in Grampian Region the vigour control treatments reduced infection at the aecidial stage in late June from 17.0 in controls to 2.9 for both dinoseb rates and 2.4 aecidia per cane in the cutting treatment; neither pre-emergence treatments were effective.

The results from both trials suggest that killing the first flush of young canes effectively delays the onset of a rust outbreak. Because no significant differences were detected between cutting and the post-emergence dinoseb treatments the main effect of vigour control may be to destroy inoculum on the first infected leaves. This work supports earlier studies on vigour control which showed that several cane diseases are controlled in dinoseb-treated plots (Ann. Rep. 1977, p.86).

(Vivienne M. Anthony, B. Williamson)

Chemical control of cane blight

Benomyl, a fungicide cleared in the United Kingdom for use with no waiting period between spraying and harvesting, has been the most effective material for control of cane blight in machine-harvested raspberries (Ann. Rep. 1980, p.86). In 1980 the interval between pre- and post-harvest sprays was shortened by using four blight treatments, each commencing with a single benomyl spray the day before picking, followed by two post-harvest sprays with triforine or triadimefon or benomyl; or a mid-harvest benomyl spray plus two post-harvest triadimefon sprays. To reduce the risk of tolerant strains of *Leptosphaeria coniothyrium* or *Botrytis cinerea* being selected,

and also to evaluate the contribution that a fruit *Botrytis* programme of dichlofluanid sprays may make to cane blight control, all four blight treatments were preceded by a fruit *Botrytis* programme; a fifth received only the *Botrytis* programme and a sixth unsprayed control was included in the design.

When assessed in February, 1981, the blight treatments including post-harvest benomyl or triforine, or mid-harvest benomyl plus triadimefon reduced the incidence of vascular lesions from 49% in unsprayed plots to 24.5, 32.7 and 26.7% respectively, but post-harvest triadimefon (41.2%) did not differ significantly from controls. On this assessment there was no difference between plots receiving only the *Botrytis* programme and the unsprayed controls.

The blight treatments including post-harvest benomyl or triforine, or mid-harvest benomyl plus triadimefon increased hand-picked yields from 1.83 t/ha in unsprayed controls to 3.32, 3.20 and 3.33 t/ha respectively; post-harvest triadimefon also increased yields to 2.65 t/ha but this increase was similar to that achieved with only a *Botrytis* programme (2.84 t/ha) and was probably due to the dichlofluanid sprays rather than the blight sprays after machine harvesting in 1980. The weight of fruit from the fourth of five hand-picked harvests was not recorded in 1981 which in part, explains the apparent low yields.

The effects of fungicide treatments on machine harvester damaged plots are always assessed by hand picking the following year. Therefore, before re-using these plots for further fungicide trials it was necessary to test for residual effects of sprays applied 2 years previously. There were no significant differences in length of dead cane, the number of dead canes or numbers of canes tied-in per plot between sprayed and unsprayed plots when plots treated with triforine, triadimefon, benomyl or imiazalil in 1979 were assessed in June, 1981. Consequently, for the first time in this series of experiments the fungicide treated machine damaged plots were compared with those picked by hand in the previous year. Less than 1% of canes died in hand-picked plots but fungicide sprays applied in machine harvested plots reduced cane death from 13.3 in unsprayed controls to 3.9, 4.7 and 6.1% for plots receiving blight sprays including post-harvested benomyl, triforine or mid-harvest benomyl with post-harvest triadimefon respectively. The *Botrytis* programme also reduced cane death to 5.9% which suggests that dichlofluanid had some effect on spread of vascular lesions after the February assessment.

In addition to the fifteen fungicides screened *in vitro* for activity against *L. coniothyrium* (Ann. Rep. 1977, p.87) two others have now been tested: fenarimol showed the highest activity (ED50$<$ 0.1 ppm) and propiconazole ($>$ 0.1 ppm, ED50 $<$ 0.5 ppm) was only slightly less effective.

(B. Williamson)

02004 *Chemical and cultural control and economic importance of strawberry red core*

Chemical control

An experiment to study some interactions of disease severity, time of treatment, plant size, yield and berry size in the cv. Cambridge Favourite was planted in a site infested with *Phytophthora fragariae* in April 1980 and metalaxyl applied at rates and times designed to achieve maximum variation in disease severity. After the first harvest in 1981 the mean yields from plants receiving a single application of 625 g/l at 1250 l/ha in September, 1980 or 1250 g in each of three band sprays in August, November 1980 (at 5000 l/ha) and February, 1981 (at 1250 l/ha), were not significantly different. All metalaxyl treatments significantly decreased disease severity but their rank order for decreasing disease severity reflected their ranking for increasing plant size and yield. Berry size increased to only a limited extent with increased plant size and the mean weight of 100 berries was greatest from those of intermediate size.

The interaction of host resistance and disease control by fungicides in the field was studied in the cultivars Cambridge Vigour, Saladin (slightly susceptible) and Cambridge Favourite (susceptible) planted in heavily infested soil treated with dazomet. High and low concentrations of captafol, aluminium tris (ethyl phosphonate) (LS 74783), and metalaxyl were compared with water applied to each cultivar in September following planting in April 1980. Assessments of diseased root length in May, 1981 indicated that, on this site, only LS 74783 and metalaxyl treatments significantly decreased disease severity in Cambridge Favourite, while all fungicides were effective with Cambridge Vigour. Although the differences between high and low rates of chemical application were not significant both cultivars tended to have less disease following high rates. Disease severity in untreated Saladin plants was lower than in the other cultivars and although all treated plants tended to have less disease, only those treated with the high rate of metalaxyl had significantly less.

When Dowco 444 was applied as granules, as a foliar spray or as a soil drench in September, 1980, disease severity in Cambridge Favourite in March, 1981 tended to be lower than in untreated plants but differences were not significant.

Fungicides containing mixtures of aluminium tris (ethyl phosphonate) with mancozeb or with folpet applied at concentrations of (0.3%/0.17%) and (0.3%/0.5%) respectively, significantly decreased the proportion of diseased roots in Cambridge Favourite in a pot experiment. Neither was as effective as aluminium tris (ethyl phosphonate) (LS 74783) alone at a concentration of 0.3%, and the mixture with folpet was phytotoxic. A metalaxyl/mancozeb mixture at a concentration of 0.05%/0.24% was as

effective as metalaxyl (0.05%) alone although it caused some damage to roots.

The effect of defoliation on the control of red core by sprays of LS 74783 or a metalaxyl/mancozeb mixture applied after re-growth, was examined in a pot experiment with the cultivars Redgauntlet, Cambridge Vigour, Cambridge Favourite and Litessa. Whereas LS74783 controlled the disease as effectively in defoliated, as in non-defoliated, plants of Redgauntlet it was significantly less effective in defoliated plants of the other cultivars. The metalaxyl/mancozeb mixture was equally effective regardless of defoliation treatment with all cultivars.

(Isabel G. Montgomerie, Diana M. Kennedy)

Biological control

In one of a series of experiments to investigate the suppressive nature of field soils, the effect of the rooting medium on subsequent infection and disease development was examined in six strawberry cultivars of diverse parentage. The root systems of young plants of similar age grown in the field and in a peat/sand compost in the glasshouse were washed, challenged with zoospores of *Phytophthora fragariae* and replanted in potting compost. No significant differences occurred in the proportion of diseased roots but the proportion of diseased root length was significantly lower in plants of all cultivars rooted in the field. The factors causing the decrease in disease are being investigated.

(Isabel G. Montgomerie, Diana M. Kennedy)

02016 *Chemical and cultural control of potato gangrene*

Contanimation of apparently clean tubers during grading

In several large-scale experiments in which tubers were assessed for gangrene in April following grading during the mid-storage period, there have sometimes been large variations between replicates and between tuber samples stored separately in clean paper sacks but derived from the same replicate. The differences could have been due to intra- or inter-replicate variability or to the presence of numerically small but concentrated sources of inoculum contaminating samples at grading. However, the extent of the variability has sometimes led to statistical tests followed by sample rejection with corresponding loss of degrees of freedom and experimental precision.

In December, 1980, none, one, two, four or eight tubers with severe gangrene lesions were added to samples of *ca.* 70 apparently healthy tubers on the reciprocating grader used as a wounding device in most of the large-scale gangrene experiments. Four replicates of each treatment level were graded and put into clean paper sacks, stored at 3°C undisturbed until late April, when the added tubers were then discarded and the remainder scored for gangrene incidence.

For the none, one, two, four and eight tuber inoculum treatments the mean gangrene incidence was 7, 10, 29, 47 and 46% respectively demonstrating that relatively small differences in numerical sources of inoculum at the time of grading could induce considerable differences in gangrene levels at the end of the storage period. The large increase resulting from adding two rather than only one infected tuber was particularly noteworthy as was the loss of an additive effect as the tuber inoculum number increased to its maximum. The small difference in incidence in doubling the number of inoculum tubers from 4 to 8 suggests an inoculum saturation level in relation to the length of time during which the tubers are wounded when they are on the reciprocating grid of the grader.

(R. A. Fox, E. Patricia Dashwood)

The effect of date of haulm destruction and harvest

In the last of series of similar field experiments, designed to investigate seasonal variations in patterns of disease incidence, haulm was destroyed on 11 August (K_1) and 11 September (K_2) and tubers were harvested at 10(H_1) and 20(H_2) day intervals thereafter. Untreated control plots were harvested on 6 occasions (some timed to coincide with haulm treatment and harvest dates) separated by 10 or 11 day intervals starting on 11 August (N_1-N_6) and there was an additional late harvest (N_7) starting on 29 October. As in previous years, tuber samples were tested at various times for inoculum levels on the surface of the periderm, for tuber tissue susceptibility, and, by inflicted standard wounds, for the interaction of surface microflora and tissue susceptibility using techniques described previously (Ann. Rep. 1980, p.89 *et seq.*).

Inoculum levels on the tuber surface

The numbers of propagules of *P. exigua* var. *foveata* on the periderm surface were very low in all tubers samples from both the control and defoliated plots, a result possibly associated with the unusually wet soil conditions that prevailed during much of the harvest period. There were minor peaks in numbers in late August (N_2 and K_1 H_1) and in late September/early October (N_5, N_6, and K_2 H_2). After haulm destruction the populations increased on the early harvested tubers (H_1 following K_1) and in the late harvested tubers (H_2 following K_2), a trend similar to that occurring in the previous year.

While the tubers were in cold storage, the inoculum levels of the N samples that were examined (N_1, N_4, and N_7) generally increased until February. In tuber samples from two of the defoliation treatments that were examined, the inoculum level of K_1 H_2 increased but that of K_2 K_2 decreased during the same period. After February the populations declined in the early harvested N_1 sample, remained steady in the mid-season samples (N_4, K_2 H_1) and rose slightly in the late harvested samples (M_7, K_2 H_2).

Tissue susceptibility

The internal tissue susceptibility of freshly harvested tubers was assessed using a standard inoculation technique and it was compared with that of tubers tested on the same date which had been held in the cold store for varying periods before hand. Susceptibility tests were also done in December, February and April in order to assess the likely reaction of tissue to wound infection caused by grading and, for the last date, by planting damage also. When inoculated immediately after harvest, the size of the rots that developed in the N tubers decreased steadily as the season progressed comfirming previously established seasonal trends. In cold store, the susceptibility of the early harvested tubers (N_1) was found to decrease at a similar rate over the first 50 days of storage ie after 50 days their tissue susceptibility was the same as that of the freshly harvested N_5 tuber sample. Thereafter the size of rots in the N_1 tubers increased to become significantly larger in December and February but the rots induced were smaller again in April. Conversely, the later harvested tubers (N_6 and N_7) did not show the initial decrease in susceptibility during the early storage period but their susceptibility gradually rose to reach levels similar to that of N_2 in December and February and then fell by a similar amount in April. The pattern for the intermediate harvests (N_2 to N_5) was more variable but susceptibility usually increased following the first 10 days of storage, decreased up to the end of October, increased in December and February and then decreased in April.

Following early defoliation tissue susceptibility was initially less than that of tubers from the corresponding no-defoliation treatment. It remained unchanged during the early storage period but then increased in December and February as did that of the N tubers. After late haulm defoliation the tissue susceptibility results were closely similar to that of the corresponding N treatments at harvest as well as in December and February. In contrast, by April the susceptibility of tubers from the defoliation treatments was less than that of the controls, particularly following the early haulm destruction.

In summary, the tissue of late harvested tubers appears more resistant to gangrene infection induced by harvest damage but it is as susceptible as that of early harvested tubers to damage caused by grading operations during the December to February storage period. As this grading damage tends to be more severe in more mature tubers (more dense, more turgid, heavier) more rots are likely to be initiated in the later than in the earlier harvested tubers at this time. High levels of tissue resistance found in all samples when tested in April were associated with the onset of shoot formation and concomitant changes in tuber physiology.

Gangrene incidence following standard wounds

At *ca.* 10 day intervals throughout the harvest period samples of freshly harvested or cold stored tubers were given the standard wound test for assessing potential gangrene and it was also used on stored tubers in

December, February and April. The induced incidence of gangrene in all samples was generally low compared to that found in previous seasons, a result that was anticipated from the low levels of inoculum detected on the surface of the tuber periderm. Gangrene potential was higher in tubers harvested in late August and lower in harvests from either the beginning or the end of the harvesting season. The highest incidence of induced rots was from samples taken from the first harvest following the first defoliation treatment (K_1H_1). When stored tubers were tested the incidence was initially variable but by December had increased in all samples except those from K_1 H_1 but by February and April it was again low and variable.

Incidence of gangrene in April following grading

The incidence of gangrene was assessed in tubers which had been graded either in December or in December and February. The double grading did not significantly affect the gangrene incidence which was generally too low and variable to demonstrate any causal relationships with the various treatments given.

Inter-relationships among the factors examined

It was unfortunate that weather and soil conditions in 1980 proved so unfavourable for the development of gangrene in an experiment intended to be the last of a long series. Nevertheless, the trend of the results, even if not always significant, corroborated the various relationships noted previously (Ann. Rep. 1980, p.91). The changes in levels of periderm populations with date of harvest matched those of 1979 and again showed a trend that was reflected in the scores for gangrene potential. Between the time of harvest and December the periderm populations increased and tissue susceptibility decreased except in late-harvested tubers, resulting in higher levels of gangrene developing in mid season samples following disease potential tests. The tissue susceptibility levels were similar to those found in previous years and the low incidence of gangrene could be attributed to the lack of inoculum on the periderm at harvest. Because of the above-average rainfall in the latter part of the 1980 season, the harvested tubers were always well covered by a layer of moist soil which not only protected the periderm from harvester damage but also provided an environment inimical to the survival of and infection by propagules of the gangrene pathogen. Many propagules are undoubtedly transferred to progeny tubers by direct contact with infected mother tubers during harvesting procedures (this Report p.97) the layers of moist soil not only minimise such contact by forming a physical barrier but, at an earlier date, were associated with early rotting of the mother tubers and thus the prior removal of the major potential inoculum source.

(R. A. Fox, E. Patricia Dashwood)

02020 *Development of histological and histochemical techniques*

Paraffin wax methods for routine histological examination of plant tissues are being phased out because of the increasing commercial availability of refined embedding resins. The purified glycol methacrylate resin now available has made it possible to embed specimens up to 1 cm^3. Problems of fixing such large specimens have been overcome by using acrolein as a 10% v/v solution in water and this results in rapid penetration. This method is not suitable for some histochemical tests for proteins, and glutaraldehyde fixation of smaller pieces must be done in parallel when necessary. Indicator dyes in glutaraldehyde have shown that it penetrates only *ca.* 2 mm into large specimens and this poor penetration accounts for many of the problems encountered with hard tissues such as barley seeds where inconsistent fixation was observed in the aleurone layer. Acrolein, despite its toxicity, penetrates rapidly and allows good infiltration by the resin.

A commercial resin, LR White, has been tested over the past year for light microscopy. Its use has allowed rapid embedding schedules to be devised, it cuts readily on both steel and glass knives and specimens of up to 1.2 cm^2 have been cut at 2 μ without tearing. The advantages of clarity and greater detail outweight the minor residual problems of curling and static with such large block faces.

(H. M. Wilson)

02021 *Immunofluorescent and fluorescent techniques in histology*

Antisera for typing Erwinia carotovora *sub sp.* atroseptica

There is a continuing need to produce antisera to identify strains of Erwinia to specific and sub-specific level and to differentiate the wide range of serogroups currently recognised. A batch of highly specific antisera, with titres of 1/4096 was raised against five strains of *Erwinia carotovora* sub species *atroseptica* using as antigen sonicated fresh whole cells. A series of eight to nine injections was given to New Zealand White rabbits, the first intramuscular was followed after a month's rest by seven to eight intravenous injections at weeky intervals. Trial bleeds and checking for specificity indicated the need for a further injection with two of the strains used. High titres were achieved but they were reduced by adsorption against other *Erwinia* spp. that, however, enhanced specificity. Following undesirable reactions in the rabbits, attributed to toxicity of the whole-cell antigen, it was decided to follow schedules used elsewhere utilising glutaraldehyde pre-treated cells.

Twelve strains of *E. carotovora* sub sp. *atroseptica*, assigned to five serogroups, were selected, four of which were used as single serogroups and four which were pairs of two different strains belonging to the same serogroup. Glutaraldehyde fixed cells were injected intramuscularly into

eight Half Lop rabbits. After six injections over a period of 8 weeks, sample bleedings gave low titres of 1/64 for the single serogroups with no agglutination reaction recorded for the paired isolate serogroups. A repeat series of booster injections raised the titre of one single strain serogroup but it did not raise the negative response of the paired isolate serogroups.

(H. M. Wilson)

VIROLOGY

B. D. HARRISON

During recent years plant virologists have become increasingly aware of the existence in virus particles of small molecules of single-stranded RNA that are not essential for infectivity or replication of the virus, and therefore are not part of its genetic material. Broadly speaking these molecules fall into two categories: *sub-genomic fragments*, which are derived from the virus genome and in some instances are known to have a function during virus multiplication, and *satellite RNA molecules*, which are replicated only in cells infected with a helper virus but do not share any substantial part of the nucleotide sequence with helper virus RNA. Both these kinds of molecule are distinct from the *viroids*, small RNA molecules that replicate independently and are not packaged in the protein coat of a helper virus.

Research during the past year has enabled several small RNA molecules associated with tobraviruses and nepoviruses to be categorised. Two sub-genomic fragments of tobacco rattle virus were characterized and one was found to act as a messenger RNA for the virus coat protein; a probable satellite RNA was identified in cultures of strawberry latent ringspot virus; naturally occurring satellite RNA of tomato black ring virus was shown to be serotype-specific; and the satellite molecules that are associated with the two serotypes of this virus were found to differ substantially in nucleotide sequence. The precise roles of sub-genomic fragments and of satellite RNA are still unclear, but their continued study seems certain to reveal important features of the mechanism of virus multiplication, and perhaps of virus evolution.

Other results of particular interest include the first observations on health of SCRI virus-free *Narcissus* stocks during field propagation; discovery of a second tulip virus that induces the classical colour-breaking of flowers; development of an improved method for detecting rubus yellow net virus; progress in the diagnosis of tobacco rattle virus in potato plants with stem-mottle disease by using complementary DNA; and evidence of serological relationships among geminiviruses, a group that includes several important crop pathogens.

In January, a JEOL T200 scanning electron microscope was installed and subsequently made available as an Institute facility.

04002 *Viruses with nematode vectors and/or multipartite genomes*

*Genome RNA of tobacco rattle virus (TRV) strain ORE-Y**

As reported previously, particles of our stock culture of TRV strain ORE-Y contain, in addition to RNA-1, two kinds of RNA-2 molecule (RNA-2a, mol.wt. 1.05×10^6; RNA-2b, mol. wt. 1.0×10^6), RNA-2b being the more abundant. However, this culture no longer produces the vivid yellow mosaic in *Nicotiana clevelandii* that was characteristic of the strain as originally described. Virus in sap stored at −20°C since 1972 produced obvious yellow symptoms in *N. clevelandii* when tested in 1978, but gradually lost this ability during 2 years of monthly sub-culture. A local-lesion isolate obtained from the symptomless plants did not induce yellow symptoms in any of nine host species tested and its particles contained RNA-2b but not RNA-2a.

The yellow symptom-producing form of ORE-Y had a lower ratio of short to long particles (1.5:1) than the symptomless form (2.5:1) and all 200 single lesions tested proved to contain isolates that did not produce TRV particles (NM forms). However, when inoculum artificially enriched in short particles was used to infect leaves, one of the resulting lesions yielded an isolate that produced virus particles and caused brilliant yellow symptoms in *N. clevelandii*. This isolate produced RNA-2a but RNA-2b was not detectable. Thus RNA-2a carries the genetic information necessary for the production of yellow symptoms whereas RNA-2b does not. RNA-2a was presumably the dominant RNA-2 in the original isolate of ORE-Y. RNA-2b, which was either present in the original isolate as a minor component or was acquired before 1972, seems to have a selective advantage under our growth conditions. Moreover, when it becomes the dominant RNA-2 species in the culture it prevents expression of yellow symptoms by the remaining small proportion of RNA-2a.

(D. J. Robinson)

Sub-genomic RNA species in particles of TRV strain SYM

RNA from purified particles of TRV strain SYM contains four species of mol.wt. 2.4, 1.5, 0.7 and 0.6×10^6 (RNA-1 to RNA-4, respectively). RNA-1 and RNA-2 comprise the virus genome, and previous work showed that a mixture of RNA-3 and RNA-4 contains some nucleotide sequences from RNA-1 and others from RNA-2. To determine whether RNA-3 is derived from RNA-1 or RNA-2, RNA preparations from TRV strains PRN and SYM, and from pseudo-recombinants between these strains, were compared by polyacrylamide gel electrophoresis. RNA-3 was detected only in RNA from TRV SYM and from the pseudo-recombinant RNA-1 (PRN)

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+ RNA-2(SYM); however, RNA-4 was detected in all four RNA preparations. This indicates that RNA-3 of TRV SYM is derived from RNA-2, and therefore RNA-4 is probably derived from RNA-1.

In further experiments done in collaboration with Dr. Christiane Fritsch[1], RNA from preparations of separated particles of TRV SYM was added to reticulocyte lysates containing ^{35}S-methionine and the translation products were analysed by polyacrylamide gel electrophoresis. The main product of translation of RNA-3 co-migrated with TRV SYM coat protein and was precipitated with antiserum to TRV SYM virus particles. Moreover when this polypeptide was treated with V8 protease from *Staphylococcus aureus*, the same range of peptides was produced as was obtained from protein of TRV SYM particles. The translation product of RNA-4 had an apparent mol.wt. of 29,000, did not react with TRV SYM antiserum and gave a pattern of peptides distinct from that of TRV SYM coat protein.

The translation experiments therefore show that RNA-3 contains the coat protein gene and so confirm that RNA-3 is a fragment of RNA-2. However, in attempts to translate severl preparations of RNA-2, only trace amounts of polypeptides were produced and these were attributable to contaminating RNA-1, RNA-3 or RNA-4. Thus whereas the RNA-2 of some other TRV strains seems to act as mRNA for coat protein synthesis *in vitro*, that of TRV SYM does not, and a specific sub-genomic fragment has this function.

(M. A. Mayo, D. J. Robinson, A. T. Jones)

*Properties of TRV isolate P from peony**

This isolate from New Zealand was found to be serologically very closely related to strain PRN from Scotland, and to have a similar host range and symptomatology, and coat protein of similar molecular weight. Isolate P and strain PRN produced long particles of similar length, but differed in the lengths, sedimentation coefficients and RNA mol.wt. of their short particles. The values for the two main kinds of short particles of strain PRN were 50 and 80nm, *ca.* 160 and 190 *S*, and 0.6 and 1.0 x 10^6 mol.wt. respectively, and those for the short particles of isolate P were 50 and 100 nm, 172 and 246 *S*, and 0.5-0.6 and 0.9-1.4 x 10^6 mol.wt. In previous studies in New Zealand, preparations of isolate P contained many particles of 150 nm but these were uncommon in preparations made at SCRI from leaves harvested from different host species, at various intervals after inoculation and at different times of the year. The particles of 100-150 nm were fragile and difficult to prepare in quantity. However, RNA extracted from these particles at an early stage of purification was of mol.wt. 0.9 to 1.4 x 10^6, suggesting that they are not end-to-end aggregates of 50 nm particles.

(P. Mills, A. T. Jones)

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[1] Institut de Biologie Moléculaire et Cellulaire, Strasbourg.

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04002 *Viruses with nematode vectors and/or multipartite genomes*

Homologies among RNA species of tomato black ring virus (TBRV)

Hybridization experiments with complementary DNA (cDNA) copies were done to compare the nucleotide sequences of the genome RNA species of strain G*, a representative of the German serotype of TBRV, with those of strains A and S (both Scottish serotype). About 30% of the sequences of RNA-1 and about 10% of the sequences of RNA-2 were found to be common to the two serotypes. However the kinetics of hybridization reactions between cDNA copies of each of these RNA species and the common sequences in the corresponding RNA species from the other serotype were from threefold to sixfold slower than the kinetics of homologous reactions. This is probably because the heterologous hybrids contain mismatched base pairs and are therefore less stable than homologous hybrids. The lower stability of heterologous hybrids was also observed in thermal denaturation experiments where, for example, cDNA copies of RNA-1 from strain G formed hybrids with RNA-1 from strain S that melted over a relatively broad range and had a melting temperature of 73°C, whereas hybrids with its homologous RNA-1 melted over a narrower range with a melting temperature of 86.5°C. The apparently common sequences are therefore not identical in the two serotypes, and estimates of the extent of sequence homology indicate only the degree of relatedness of RNA species and are not precise measures of the number of common residues.

(Susan M. Dodd, D. J. Robinson)

Behaviour of mixtures of genome parts from different serotypes of tomato black ring virus (TBRV)

For TBRV to multiply detectably and produce symptoms in plants, inocula must contain both genome parts, RNA-1 and RNA-2. In previous work it was also shown that the combination of RNA-1 (strain G*) + RNA-2 (strain A) infected plants, although symptoms were somewhat slow to develop, but the reverse combination (RNA-1(A) + RNA-2(G)) did not. This phenomenon has now been examined in more detail by inoculating leaf discs and mesophyll protoplasts of tobacco cv. Xanthi with these pseudo-recombinant mixtures of TBRV RNA.

Inocula of RNA-1(G) + RNA-2(A) infected leaf discs but the virus became serologically detectable in these discs about 1 day later than in discs inoculated with either TBRV strain G or TBRV strain A. No such delay occurred, however, when protoplasts were infected with similar inocula.

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This suggests that the slow multiplication of the pseudo-recombinant mixture in leaves may be caused by a retarded spread of virus from cell to cell and not by its slower multiplication in infected cells.

When protoplasts were inoculated with RNA-1(A) + RNA-2(G) and cultured, no infectivity was detected in extracts made either with buffer or with phenol, and the protoplasts could not be stained with fluorescent antibody to particles of TBRV(G). However, TBRV(G) coat protein was detected in buffer extracts by enzyme-linked immunosorbent assay (ELISA), in amounts ranging from 1 to 10% of that recovered from similar protoplasts inoculated with RNA-1(G) + RNA-2(G). Immunosorbent electron microscopy revealed virus-like particles in buffer extracts of protoplasts inoculated with RNA-1(A) + RNA-2(G) and, on centrifugation in sucrose density gradients, all the virus coat protein detectable by ELISA sedimented at the same rate as the nucleic acid-free protein shells of TBRV.

Although they were not infective, phenol extracts of protoplasts inoculated with RNA-1(A) + RNA-2(G) were also tested for the presence of each RNA by adding either RNA-2(A) or RNA-1(G) and determining the resulting infectivity for plants. These tests showed that RNA-1(A) had multiplied in the protoplasts (as it does when inoculated without any added RNA-2) but no increase was detected in the amount of infective RNA-2(G). Thus in these protoplasts TBRV-G coat protein is synthesized and assembles into RNA-free particles but does not form particles containing RNA-1(A) whereas in protoplasts inoculated with the opposite pseudo-recombinant mixture, TBRV-A coat protein not only assembles into RNA-free particles but also forms nucleoprotein particles that contain either RNA-2(A) or RNA-1(G).

(M. A. Mayo, H. Barker)

Specificity of the dependence of satellite RNA on tomato black ring virus (TBRV)

Many but not all isolates of TBRV contain a satellite RNA which is packaged in TBRV coat protein to form additional sedimenting and bouyant-density components. Previous studies showed that TBRV strain S did not support multiplication of satellite RNA from strain G, which belongs to a different serotype, nor did TBRV-G support multiplication of satellite RNA from TBRV-S, although both isolates supported multiplication of their homologous satellite RNA. In further experiments, TBRV-A, a Scottish isolate which is serologically closely related to TBRV-S, behaved like TBRV-S, whereas TBRV-E and the celery yellow vein strain (TBRV-CYV), English isolates that are serologically close to TBRV-G, behaved like TBRV-G. TBRV-A is naturally free of satellite RNA but TBRV-E and TBRV-CYV each posses a satellite RNA and these

satellites behaved like that from TBRV-G. Grapevine chrome mosaic virus* (GCMV), a virus from Hungary which is very distantly serologically related to both TBRV-S and TBRV-G, and does not possess a satellite RNA, did not support multiplication of any of the four satellite RNA species tested. Thus it at first appeared that the type of satellite RNA that can associate with a TBRV isolate is determined by the specificity of the coat protein. However, a pseudo-recombinant, TBRV-GA, which possesses RNA-1 from TBRV-G and RNA-2 from TBRV-A and therefore has coat protein like that of TBRV-S (coat protein specificity is determined by RNA-2), supported satellite RNA from TBRV-G but apparently not that from TBRV-S. Thus production of particles containing satellite RNA seems to be determined primarily by TBRV RNA-1, which carries the genetic information required for replication of TBRV RNA, and is less dependent on RNA-2 because satellite RNA from TBRV-G can be packaged in coat protein of either TBRV-G or TBRV-A. This is the first explicit evidence for any plant virus satellite RNA being dependent on its helper virus for function(s) other than packaging in coat protein (although dependence for replication is often assumed).

(A. F. Murant, J. H. Raschké)

Previous studies showed that satellite RNA from TBRV-S and TBRV-G are translated *in vitro* into proteins of the same mol.wt. *(ca.* 48,000) but of different chemical composition. In further colloborative tests with Dr Christiane Fritsch[1], analysis of T_1 ribonuclease digests and peptide mapping of satellite RNA translation products showed that the nucleotide sequences of the satellite RNA species from TBRV-G, TBRV-E and TBRV-CYV are closely similar, but differ somewhat from those of satellite RNA from TBRV-S and from another Scottish isolate, TBRV-Gilchrist. However, there are sequences similarities among all these TBRV satellite RNA species, whereas satellite RNA from myrobalan latent ringspot virus* (MLRV) is totally distinct.

(A. F. Murant, M. A. Mayo)

Comparisons of hybridization with homologous and heterologous cDNA copies indicated that satellite RNA species from TBRV-S and TBRV-G have about 25% of their nucleotide sequences in common.

(D. J. Robinson)

Satellite-like RNA of strawberry latent ringspot virus (SLRV)

Previous work showed that RNA extracted from particles of the type isolate (T39) of SLRV contained three RNA species (RNA-1, RNA-2 and RNA-3)

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[1] Institut de Biologie Moléculaire et Cellulaire, Strasbourg.

whereas that from particles of the isolate MJ contained only RNA-1 and RNA-2. RNA-3 was also found to resemble RNA-1 and RNA-2 in being polyadenylated and covalently linked to a small protein, and it was suggested that RNA-3 is a satellite RNA. In further experiments, RNA species from isolate T39 were separated by electrophoresis in acrylamide gel and the region containing RNA-1 and RNA-2 was used to inoculate *C. amaranticolor*. From well separated lesions several isolates were obtained which remained free of RNA-3 after three passages in *N. clevelandii* but were otherwise normal. RNA-3 was, however, produced when added to inocula of these isolates. These results, and the failure of purified RNA-3 to induce symptoms in *C. quinoa* or *C. amaranticolor*, suggest that RNA-3 is a satellite RNA.

(M. A. Mayo, H. Barker)

A possible role for the genome-linked protein of raspberry ringspot virus

It was previously shown that raspberry ringspot virus RNA is covalently attached to a small protein and that when the RNA is treated with proteinase K its infectivity for plants is decreased twofold to tenfold. The buffer used in these assays normally contained bentonite (0.6 mg/ml), which is thought to protect RNA from degradation by ribonuclease. Further tests showed that the extent of the decrease in infectivity of RNA caused by proteinase K treatment is related to the concentration of bentonite added to the inoculum. Most decrease was observed in the absence of bentonite, and least when relatively high concentrations of bentonite (3 mg/ml) were used, although excessive concentrations (15 mg/ml) inhibited infectivity. These results suggest that bentonite can partially substitute for the portion of the genome-linked protein removed by proteinase K, possibly because the genome-linked protein acts by protecting the virus RNA from degradation during inoculation.

(H. Barker, M. A. Mayo)

VIRUSES OF FLOWER BULBS

04010 *Viruses infecting bulbous ornamentals*

Tulip chlorotic blotch virus[*]

Last year some properties of a virus from tulip with particles *ca.* 750 nm long were reported and the suggestion made that it was not tulip breaking virus. Two isolates of this virus, provisionally named tulip chlorotic blotch, have now been transmitted by inoculation with sap and by aphids (*Myzus persicae*) to tulip cultivars Apeldoorn, Paul Richter and Merry Widow, all of which developed flower-breaking symptoms. However, in immunosorbent

[*] Held under DAFS licence.

electron microscopy tests, a Dutch antiserum to tulip breaking virus which reacted with particles of an isolate of tulip breaking virus from lily did not react with those of tulip chlorotic blotch virus. Thus it seems that the classical flower-breaking symptoms can be induced by two different viruses.

(W. P. Mowat, G. H. Duncan)

Particle structure of tulip virus X (TVX)

Diffraction studies of TVX particles were made in conjunction with M. M. Radwan[1] and H. R. Wilson[1]. High resolution electron micrographs, of particles negatively stained with uranyl formate/sodium hydroxide, were used as the subjects for optical diffraction. Measurements of the diffraction patterns suggest that the particle structure is repeated in five turns of its primary helix, which has a pitch of 3.25 nm, and that there are 7.8 or 8.8 subunits in each turn. The same figures also are suggested by measurements of patterns obtained by X-ray diffraction of samples of purified TVX particles. An additional feature at a particle radius of 3.3 nm, probably RNA, and an axial hole of 3.0 nm diameter, were also detected. These parameters are similar to those determined for other potexviruses.

(G. H. Duncan)

Virus-indexing methods

The value of ELISA for detecting narcissus mosaic and narcissus tip necrosis viruses in *Narcissus* (Ann. Rep. 1977, p.96) has since been confirmed repeatedly, with the upper part of an outer leaf, sampled after flowering, being a reliable source of both viruses. In contrast, narcissus latent virus was detected by ELISA only in undiluted sap from outer leaves and not in sap from inner leaves, flower stem or flowers. The reason for the apparent insensitivity of the test for this virus is not yet clear.

(W. P. Mowat)

04011 *Production of virus-tested bulb stocks*

Propagation of virus-tested Narcissus

In 1981 the sixth annual batch of virus-tested clones was released by SCRI at the request of Scottish Nuclear Stock Association (Flower Bulbs) Ltd for further multiplication by East of Scotland College of Agriculture and North of Scotland College of Agriculture. The consignment consisted of 28 kg of bulbs of cultivars Barrett Browning, Carlton, Sempre Avanti and Verger. Supplies of virus-tested stocks of these cultivars, and of cv. Red Devon, are being maintained at SCRI in quantities suitable for re-issue on demand. It is planned to release another three important cultivars (Fortune, Golden

[1] Carnegie Laboratory of Physics, University of Dundee.

Harvest and King Alfred) in 1983 or 1984, and sufficient material should be available for continued annual releases of these cultivars.

In some years, dormancy in the first year has seriously decreased the efficiency of the twin-scale method of propagation, but previous evidence suggested that this problem could be greatly minimised by extending the period of incubation of twin-scales at 23°C from 12 to 16 wk. However, a second trial gave inconclusive results because, although virus-tested bulbs of the dormancy-prone cultivar Carlton were used, the material lacked intrinsic dormancy. Nevertheless until another improved empirical method of incubation is found, or the factors that determine dormancy are understood, it is recommended that *Narcissus* twin-scales should be incubated for 16 wk at 23°C.

(W. P. Mowat)

Virus-indexing of virus-tested stocks after further propagation

Representative leaf samples from *Narcissus* plants in the second stage of propagation by ESCA and NSCA were tested for narcissus mosaic and narcissus tip necrosis viruses by ELISA in the year of their release to SNSA (Flower Bulbs) Ltd for field propagation. No infection was found.

Similar tests were made on leaf extracts from 480 plants in the second year of field propagation by SNSA (Flower Bulbs) Ltd. Again neither virus was detected. In addition, no infection with nepoviruses was detected by infectivity tests on 100 plants. These results support the view that the health of stocks can be maintained during field propagation providing that suitable precautions are taken.

(W. P. Mowat)

RUBUS VIRUSES

04003 *Viruses infecting raspberry*

A severe leaf curling symptom induced in cv. Norfolk Giant raspberry

A plant of a red raspberry selection showing yellows disease in Kent contained raspberry bushy dwarf virus but was apparently free from other mechanically transmissible viruses and from black raspberry necrosis, raspberry leaf mottle, raspberry leaf spot and raspberry vein chlorosis viruses. Norfolk Giant raspberry plants graft inoculated with scions from this plant developed severe leaf curling symptoms near the tips of primocanes. Although the symptoms closely resemble those induced by aphid-borne raspberry leaf curl virus found in North America, no symptoms occurred in plants of recognised indicators of this virus (*Rubus henryi*, *R. occidentalis* and *R. phoenicolasius*) or in several other red raspberry cultivars 6 months after graft inoculation. The disease therefore may be previously undescribed.

(A. T. Jones)

An outbreak of raspberry ringspot virus in cv. Glen Clova raspberry

Glen Clova raspberry has been grown in commerce for almost 10 years and in Scotland now occupies nearly half of the raspberry acreage. Although it can be infected experimentally with three nepoviruses — arabis mosaic, raspberry ringspot and tomato black ring viruses — the only naturally occurring nepovirus infections found previously were with arabis mosaic virus in England, Wales and Northern Ireland. During 1981, two separate samples of Glen Clova from Scotland were found to be infected with raspberry ringspot virus. In one of these, supplied by D. W. Purdie[1] from a plantation in Fife, the leaves showed chlorotic ringspots and mottling. This plantation had large patches where Glen Clova plants were stunted and where many of the plants showed foliar symptoms. Soil from such affected areas contained many *Longidorus elongatus*.

(A. T. Jones, A. F. Murant)

Cherry rasp leaf virus in imported raspberry

The virus* detected in Tweddell imported from Canada (Ann. Rep. 1980, p.100) was identified as an isolate of cherry rasp leaf virus (CRLV), a virus not previously recorded in *Rubus*. In North America this virus is transmitted by *Xiphinema americanum*, a nematode species not found in Scotland. The raspberry isolate of CRLV shares many properties with nepoviruses. For example, purified preparations of virus particles contain two nucleoprotein components with sedimentation coefficients of 90 *S* and 116 *S*; the particles contain two RNA species with mol.wt. (estimated by electrophoresis in agarose gels after denaturation in glyoxal) of *ca.* 1.3×10^6 and 2.5×10^6, and the infectivity of virus nucleic acid was abolished by incubation with proteinase K. However, unlike definitive nepoviruses, preparations of virus protein contained two polypeptides with estimated mol.wt., determined by polyacrylamide gel electrophoresis, of 20,000 and 22,000.

(A. T. Jones, Susan Badenoch, M. A. Mayo)

Virus-like diseases of hybrid Rubus *and blackberry*

Because of the growing commercial interest in hybrid berries, increasing efforts are being made to identify and assess the importance of viruses in such material. Tayberry plantations were examined at intervals during the year for aphids that might act as virus vectors. Many large colonies of *Sitobion fragariae* were found early in the year but no *Amphorophora idaei* were observed. The apparent resistance to *A. idaei* was confirmed in

[1] East of Scotland College of Agriculture.
* Held under DAFS licence.

laboratory tests. In some years *S. fragariae* is also common on some red raspberry cultivars, including those containing major gene resistance to *A. idaei*. Tests of its ability to transmit a range of *Rubus* viruses have therefore begun.

(A. T. Jones, Susan Badenoch)

In addition to the disease of Tayberry mentioned previously (Ann. Rep. 1980, p.100), a few plants of blackberry cultivars Bedford Giant, Bedford Thornless, Chehalem and Marion, and of Boysen hybrid berry, were observed in Scotland showing virus-like symptoms, mainly a chlorotic mottle. Affected plants were mostly slower to break dormancy in spring and some were stunted. In addition, a distinct virus-like disease was observed in Bedford Thornless blackberry. Plants were characterized by mottling and severe crinkling of the leaves, especially on the fruiting cane, and most fruiting laterals were sterile.

Some Bedford Giant and Bedford Thornless blackberry plants showing a pronounced chlorotic mottle contained raspberry leaf mottle or raspberry leaf spot virus but others did not. However, when grafted to *R. occidentalis*, all scions from affected plants induced tip necrosis suggestive of black raspberry necrosis virus. Whether this virus is the cause of the disease is not known.

(A. T. Jones)

04004 *Production of virus-tested raspberry stocks*

During the year, seven imported *Rubus* species and 19 selections from the SCRI *Rubus* breeding programme were indexed for virus infection. In attempts to improve detection of viruses, further *Rubus* species were screened as indicators. Preliminary tests suggest that three species, *R. illicebrocus*, *R. macraei* and *R. trivialis* may be superior to *R. occidentalis* as indicators for rubus yellow net virus (RYNV).

(A. T. Jones, S. Badenoch)

The small bacilliform particles of RYNV (*ca.* 130 x 30 nm) are often difficult to detect in plants, even in the recommended indicator *R. occidentalis*. They can be found in leaf cells by electron microscopy of ultrathin sections but are rarely seen by electron microscopy of sap, even when a range of extraction procedures and negative stains is used. Much better success in detecting such particles was achieved by extracting sap of infected *R. macraei* in 4% polyvinyl pyrrolidone and staining with 2% ammonium molybdate, pH 6.5.

(A. T. Jones, I. M. Roberts)

04007 *Viruses infecting umbelliferous crop plants*

Carrot red leaf (CRLV) and carrot mottle (CMotV) viruses

Preparations of protein from CRLV particles that had been centrifuged both in rate zonal sucrose density gradients and in CsCl equilibrium gradients were analysed by electrophoresis in polyacrylamide/SDS gels; they contained a major polypeptide of mol.wt. *ca.* 25,000 and three minor polypeptides of mol.wt. *ca.* 40,000, 52,000 and 57,000. In comparative tests a preparation of protein from particles of potato leaf roll virus (PLRV) yielded a major polypeptide of mol.wt. *ca.* 25,000 and three minor ones of mol.wt. 50,000, 75,000 and 85,000. The origin of the minor polypeptides in these preparations is unknown.

Nucleic acid preparations from purified particles of CRLV were found to contain a single species when analysed by electrophoresis in polyacrylamide gels; it co-migrated with that found in preparations of PLRV RNA and had an estimated mol.wt. of 1.8×10^6. Particles in purified preparations made from chervil tissue infected with both CRLV and CMotV were indistinguishable from those in preparations from plants infected with CRLV alone but possessed CMotV infectivity as shown by aphid-injection tests or by manual inoculation to *Nicotiana clevelandii*. However, only a single nucleic acid species with the same mobility as that of CRLV was detected in these particles.

(P. M. Waterhouse, A. F. Murant)

Tomato black ring virus (TBRV) in carrot

Carrot plants sent by S. A. Hill[1] from a crop growing near Wisbech, Cambs contained TBRV, German serotype. The affected plants were stunted, chlorotic and faintly mottled, and they occurred in patches amounting to about 10% of the crop area in one field and 50% of that in another. This is the first report of TBRV in carrot in Britain; the only previous report is from Poland.

(A. F. Murant)

POTATO VIRUSES

04001 *Potato viruses, especially soil-borne viruses*

Diagnosis of tobacco rattle virus (TRV) in potato plants with stem-mottle disease

Stem-mottle disease has long been associated with TRV, but a reliable diagnostic test for this virus in potato is still not available. Sap inocula from

[1] Agricultural Development & Advisory Service, Cambridge.

any affected plants induce only a few lesions in indicator plants, or none at all, and no readily multiplying forms of the virus can be cultured from these lesions.

These findings were confirmed and buffer extracts of affected leaf tissue were shown to be non-infective after freezing and thawing, a procedure that has little effect on the infectivity of sap containing TRV nucleoprotein particles. Also, no TRV particles were found in sap by immunosorbent electron microscopy. In contrast, nucleic acid preparations from affected leaves were very infective for test plants in which, however, TRV particles were not produced. The isolates therefore resemble TRV isolates of the NM type, *i.e.* isolates which consist of RNA-1, replicating on its own, and which lack RNA-2 and therefore do not produce TRV particles.

Attempts were made to devise a reliable diagnostic method for such isolates. The first procedure consisted of adding purified S particles (which contain RNA-2) of a M-type isolate of the virus, to nucleic acid inocula from affected potato foliage. When the relative concentrations of the two components of the inocula were suitably adjusted, *N. clevelandii* test plants yielded TRV particles of both characteristic sizes whereas no such particles were produced in plants inoculated either with the nucleic acid preparations or with S particles alone. Reconstitution of the TRV genome therefore enabled serological tests on sap from the *N. clevelandii* plants to be used to identify the virus. Although theoretically sound, this method was technically demanding, because it was difficult to obtain preparations of S particles that were completely free from particles containing RNA-1.

In a second method, ^{3}H-labelled DNA complementary in nucleotide sequence (cDNA) to RNA-1 was used to detect RNA-1 sequences in extracts of potato foliage. Although the concentration of TRV RNA-1 in potato leaves was only about a tenth of that in *N. clevelandii* leaves infected with the same NM isolate, the test differentiated nearly all nucleic acid samples from stem-mottle affected foliage from those from unaffected foliage, and the few borderline detections of TRV were confirmed by extending the incubation period allowed for hybridization. The method worked well for leaf samples from potato plants grown in the glasshouse, gauzehouse or field, and for all three cultivars tested. It also differentiated TRV-infected plants from those infected with potato mop-top virus, which can cause similar symptoms in potato. A small-scale survey indicated that all the stem-mottle affected plants sampled contained NM isolates of TRV. The inability of NM isolates to invade host plants systemically *via* vascular tissue perhaps explains the typical restriction of stem-mottle symptoms to only one or a few of the shoots produced by an infected tuber.

(B. D. Harrison, D. J. Robinson)

Infection of potato leaf protoplasts with viruses

Studies were begun of the effect of different resistance genes in potato on the behaviour of viruses at the cellular level. As an important preliminary to

work on the main potato viruses, a method was devised of preparing and infecting protoplasts from potato leaves with other viruses. Consistent results were obtained with the youngest fully expanded leaves on 20-30 cm-tall plants grown in a glasshouse at 25°C and provided with supplementary light (10,000-15,000 lux) for 12 h per day. After abrading the lower leaf surface with Carborundum, 6 cm-diameter discs were cut, and incubated at 30°C for 1 h in 0.4 M mannitol followed by 3 h in solution containing 0.5% pectinase and 2% cellulase. The mannitol concentration was also kept at 0.4 M during subsequent washing and inoculation, which was by the poly-L-ornithine method. Most of the resulting protoplasts were viable after incubation for 2 days and were readily infected with several viruses used as test inocula. Up to 80% became infected with tobacco ringspot virus.

In tests to investigate the susceptibility of the protoplasts to infection with potato leafroll virus (PLRV), which is thought to be confined to the vascular tissue of intact plants, up to 42% of protoplasts of cv. Kerr's Pink became infected. This indicates that, although mesophyll cells are not normally infected by PLRV, they are biochemically competent to support multiplication of the virus.

Comparisons were also begun of the behaviour of PLRV in protoplasts of cultivars with or without field resistance to infection with the virus. The first results showed no consistent difference, in percentage of protoplasts infected, between Kerr's Pink (a susceptible cultivar) and three cultivars that have multigenically-controlled field resistance to infection, Kirsty, Pentland Crown and Sheriff.

(H. Barker, B. D. Harrison)

Messenger properties of potato leafroll virus (PLRV) RNA

Previous work showed that PLRV RNA can infect tobacco protoplasts suggesting that, like the RNA of most plant viruses, PLRV RNA is positive-stranded. When PLRV RNA was added to reticulocyte lysates containing either ^{35}S-methionine or ^{3}H-leucine the synthesis of several radioactive polypeptides was induced. The main translation product had a mol.wt. of *ca.* 71,000 and the largest product was of mol.wt. *ca.* 125,000. No protein was detected that co-migrated with PLRV coat protein when the translation products were analyzed by polyacrylamide gel electrophoresis. It is thus likely that PLRV RNA acts as a messenger RNA *in vivo* and therefore is positive-stranded.

(M. A. Mayo, H. Barker, B. D. Harrison)

04014 *Identification of viruses in relation to diseases of other crop plants*

Turnip crinkle virus (TCV) in swede and turnip

The spread of TCV was studied in small field plots of two cultivars of turnip and three cultivars of swede, each plot containing a row of infector plants that were manually inoculated in May with a satellite-free isolate of TCV. In September the virus was readily detected by ELISA in leaf extracts from all inoculated plants of the turnip cultivars Brimmond and Finlay, and all bait plants had become infected, although their leaves were not in contact with those of the infectors. In contrast, TCV was not detected in all the swede infector plants, it occurred in much lower concentration than in turnip and it was only detectable in some parts of some leaves of infected plants. Most infector plants of cultivars Ruta Otofte and Criffel were infected, but TCV was detected in few of those of cv. Scotia and in none of the swede bait plants. Symptoms of infection developed only in the turnip plants. These results indicate that turnip is a good host of TCV, develops symptoms and is susceptible to infection in the field whereas swede is a poor host, remains symptomless and seems resistant to field infection.

In other exploratory tests, TCV was detected by ELISA in six out of 11 flea-beetles (its presumed vectors) collected in one of the turnip plots in September. ELISA may therefore prove useful for detecting TCV in vector flea-beetles in epidemiological studies, but satisfactory methods of estimating and sampling populations of these insects have yet to be devized.

(W. P. Mowat)

*Cassava latent virus (CLV)**

Fluorescent antibody to CLV particles was used in further studies on the distribution of CLV particle antigen in tissues and cells. In sections cut with a cryostat, virus antigen occurred mainly in phloem parenchyma and companion cells of *Nicotiana benthamiana* leaves but some cells in the cortex, mesophyll and epidermis were also infected. The antigen was confined to the nucleus in nearly all cells but in a few the entire cell contents were stained.

CLV was detectable by ELISA in *N. benthamiana* leaf extracts diluted to 1/10,000 but was rarely detected in cassava at dilutions greater than 1/500 Research elsewhere has indicated that CLV is associated with African cassava mosaic disease, but repeated tests at SCRI on mosaic-affected cassava plants of Angolan origin indicated that some were free of CLV. The same result was obtained when immunosorbent electron microscopy or

* Held under DAFS licence.

manual inoculation of sap to *N. benthamiana* was used to detect the virus instead of ELISA. This suggests that the mosaic symptoms were caused by a pathogen other than CLV, but no such agent was found by inoculating sap to a range of indicator plants or by electron microscopy of leaf extracts.

Three kinds of serological test (gel-diffusion precipitin test, immunosorbent electron microscopy and density-gradient centrifugation of virus/antibody mixtures) indicated that CLV is related to bean golden mosaic virus. Evidence was also obtained of a distant relationship to beet curly top virus but none was detected to chloris striate mosaic, maize streak, tobacco leaf curl or tobacco yellow dwarf viruses.

(J. C. Sequeira, B. D. Harrison)

Previous work showed that CLV particles contain circular molecules of single-stranded DNA. Further studies on the structure of these molecules were started in collaboration with workers at the John Innes Institute.

Tests on DNA from CLV-infected *Nicotiana benthamiana* leaves detected a small proportion of circular double-stranded molecules with a contour length of 800 to 850 nm, corresponding to a mol.wt. of 1.6 to 1.7 x 10^6. These molecules, which are of the size expected for a replicative form of the virus genome, were partially purified by chromatography on acridine yellow ED gel.

(D. J. Robinson, J. C. Sequeira, G. H. Duncan, B. D. Harrison)

Virus complex in tomato in Nigeria

In continuing work with Dr. J. L. Lapido[1], a new virus complex from tomato was examined. Initial studies indicated the presence of two distinct components, one of which was aphid transmitted and was identified by immunoelectron microscopy (IEM) as pepper veinal mottle virus. The other component contained at least two viruses, both with filamentous particles. In IEM tests, particles of one of these viruses reacted strongly with antiserum to cowpea mild mottle virus; the other particles did not react with this antiserum or with several antisera to other viruses in the carlavirus, potexvirus or potyvirus groups.

(I. M. Roberts)

An additional RNA species in particles of lucerne transient streak virus (LTSV) *

Although the infectivity of RNA extracted from purified LTSV particles, assessed by ability to produce necrotic local lesions in *Chenopodium amaranticolor*, is abolished by incubation with proteinase K (Ann. Rep.

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[1] University of Ife, Ile-Ife, Nigeria.

* Held under DAFS licence.

1980), further studies showed that a little residual infectivity detectable by the induction of faint chlorotic local lesions sometimes survives this treatment. When virus was cultured from individual chlorotic lesions, inoculated leaves again developed cholorotic lesions, which were found to contain LTSV particles. Electrophoresis in 5% polyacrylamide gels of RNA from *C. amaranticolor* leaves showing only necrotic or only chlorotic lesions detected a RNA species of estimated mol.wt. 0.1-0.2 x 10^6 in the leaves with necrotic lesions but not in those with chlorotic lesions. This second RNA species, together with the species of mol.wt. 1.4 x 10^6 that was described previously, was also detected in nucleic acid from purified particles of the original culture of LTSV. LTSV seems able to replicate in plants independently of this small RNA, which itself may be a satellite RNA or viroid able to affect lesion type in *C. amaranticolor*.

(A. T. Jones, M. A. Mayo)

*Elderberry latent virus**

Some workers have suggested that this virus has properties similar to those of carnation mottle virus. However, reinvestigation of its physical properties has confirmed and reinforced the earlier conclusion that elderberry latent virus differs from this and allied viruses. Its particles have a sedimentation coefficient of 112 *S* and contain protein of mol.wt. *ca.* 43,000, and electrophoresis of preparations of virus RNA in agarose gels after denaturation in glyoxal showed small amounts of species of estimated mol.wt. 1.2 x 10^6 and 0.54 x 10^6 in addition to the most abundant species of mol.wt. 1.32 x 10^6.

(A. T. Jones, S. Badenoch)

TECHNIQUES

04021 *Techniques for electron microscopy*

Simplified calibration of electron microscopes with catalase

Catalase crystals are commonly used to calibrate electron microscopes in the x 20,000-150,000 magnification range. This usually involves preparing prints from micrographs of the crystals, marking and measuring each micrograph and print, and then calculating the magnifications. However, with minor changes, the use of catalase can be extended to lower magnifications and the calculations greatly simplified.

Micrographs are examined under a stereo microscope (10-40 x) and two crystal lattice lines, 30-40 spacings apart, scored with a sharp scalpel blade. The micrographs are then cut to fit 5 cm x 5 cm slide holders and projected in an ordinary slide projector onto a sheet of paper. The lattice scores are

* Held under DAFS licence.

marked, the number of spacings counted, and the results from a complete magnification series recorded on a single sheet of paper. The calculation is simplified to

$$\text{Magnification} = \frac{\text{Distance between score marks (mm)}}{\text{Number of lattice spaces}} \times C$$

where C is a constant calculated from the lattice spacing and projector enlargement.

This method allows calibrations to be done quickly and provides a permanent record that is easily checked without the need for prints. The use of a projector makes considerable enlargement possible, thus extending the use of catalase to calibration of magnifications as low as x 5,000.

(I. M. Roberts)

ZOOLOGY

D. L. TRUDGILL

It has long been assumed that all potato cultivars are equally susceptible to damage by potato cyst nematodes (PCN). Research during the past 3 years, supported by the Potato Marketing Board, has shown this is not so. Some cultivars have proved to be much more tolerant of PCN damage than others and, although the most tolerant are also resistant, some of the least tolerant were also resistant to PCN. Glasshouse experiments indicate that PCN causes a marked reduction in the efficiency of the roots of attacked plants, and tolerant cultivars partly compensate for this damage by producing extra roots.

Differences in the tolerance of raspberry cultivars to a replanting disorder have also been observed, and the soil sterilant chemical dazomet has been shown to be effective against both the nematode *(Pratylenchus penetrans)* and fungal components of the disorder.

Studies on the ecology of ectoparasitic nematodes are continuing and a long-term trial using six crop species shows that the numbers of *Longidorus elongatus*, and of four other species of ectoparasitic nematodes are inversely correlated with the numbers of predatory nematodes. New techniques for histochemically quantifying changes in roots fed upon by *Longidorus* and *Xiphinema* are also helping us to understand what makes good or poor plant hosts.

Thiofanox has again been shown to be effective for controlling the spread of potato leaf roll virus (PLRV) in potato. However, the results indicate thiofanox is only partially effective when the virus is coming from outside the treated crop. Early haulm destruction (mid-August) did not, however, decrease the incidence of PLRV compared with haulm destruction in late August in a crop rogued of initial infectors by July.

NEMATOLOGY

05010 *Assessment of the damage caused by potato cyst and other plant parasitic nematodes in Scotland*

Tolerance of potato cultivars to damage by potato cyst nematodes (Globodera rostochiensis *and* G. pallida)

A series of co-ordinated trials with the North of Scotland College of Agriculture and the Agricultural Advisory and Development Service in

England examined the response of six potato cultivars to a nematicide (oxamyl, 5.6 kg a.i./ha) at ten sites with widely differing numbers of *G. rostochiensis* or *G. pallida*. At two sites with no potato cyst nematode (PCN) the nematicide had no consistent effect on yield, except that the yields of Cara and Maris Piper were decreased slightly. At sites with many *G. rostochiensis* the yields of Cara and Maris Piper were increased least and those of Pentland Dell and Corsair (F49/52) were increased most by the nematicide. At sites with many *G. pallida* all cultivars except Cara showed large increases in yield when treated with a nematicide.

The results of these trials confirm those of previous investigations which showed that wide differences in tolerance to PCN damage occurred between some potato cultivars. When the results were presented as genotype/environment interactions Cara was consistently the most tolerant and Pentland Dell the least tolerant of all the cultivars tested. In other field trials Cara, Maris Piper and Pentland Javelin were identified as tolerant to *G. rostochiensis* damage whereas Pentland Dell, Corsair, Stormont Enterprise, Maris Peer and Maris Anchor were comparatively intolerant. Pentland Crown was more tolerant than Pentland Dell but less tolerant than Maris Piper in soil infested with *G. rostochiensis*. In soil infested with *G. pallida* the tolerance of Maris Piper was similar to that of Pentland Crown.

In experiments in large pots (30 cm) a marked difference between tolerant and intolerant cultivars in the effect of PCN on root growth was observed. Initially PCN retarded the root growth of all cultivars but the tolerant cultivars responded to this damage by producing many new roots. As a consequence the root systems of tolerant cultivars often grew larger in infested than in uninfested soil. Thus, Cara produced a mean of 74 g of roots in heavily infested soil when treated with a nematicide and 98 g of roots without the nematicide, whereas Stormont Enterprise produced a mean of 53 g of root in treated and 26 g in untreated soil.

Although PCN increases root growth in tolerant cultivars, top growth and yield are usually decreased. This is partly because PCN damage greatly reduces the effectiveness with which potato roots take up nutrients and water and hence the weight of top that can be supported. Thus, in heavily infested soil 1 g of Cara root (385 cm length) supported 6.5 g of top in nematicide treated soil but 1 g of root (304 cm) supported only 2.0 g of top in untreated soil. With Stormont Enterprise 1 g of root supported 4.8 g of top in treated soil and 1.6 g in untreated soil. The combined effect in Stormont Enterprise of the reduction in root length and root efficiency resulted in total plant weight and tuber yield being reduced in the untreated soil by 84 and 89% respectively. For Cara the loss in root efficiency was partly off-set by the increase in root weight so that in untreated soil the decrease in total plant weight (61%) and yield (76%) was less.

Although some cultivars were consistent in their relative tolerance, others tended to vary between experiments. For example, Maris Anchor appeared much less tolerant to PCN when grown in the field than in large pots.

Experiments in a controlled environment cabinet in which plants could be grown at two root temperatures, but a similar air temperature (15-18°C), provided a possible explanation for this difference by showing that Maris Anchor was more severely damaged by PCN in soil at 9 than at 15°C. In untreated, heavily infested soil, after 6 wk growth the mean root weight of Maris Anchor was at 9°C was 11.5 g and at 15°C was 16.5 g. In nematicide treated soil the root system grew larger at 9°C (32.2 g) than at 15° (17.9 g) further emphasising the effect of temperature on the susceptibility of roots to damage by PCN.

A study has been started on methods of screening in small pots for differences in tolerance and plants grown from rooted cuttings gave promising results. Cara and Maris Piper produced larger root systems in untreated, PCN infested soil (1.94 and 1.54 g respectively) than in soil treated with a nematicide (1.59 and 1.34 g) whereas the roots of Pentland Crown and Maris Anchor were less in the untreated soil (1.38 and 0.54 g) than in the treated (1.78 and 1.15 g respectively).

(D. L. Trudgill, Lucy M. Cotes)

Root-knot nematodes (Meloidogyne spp.)

Root-knot nematodes are major pests in warm regions of the world, but two species are known to occur in Scotland. One, *M. naasi* was first discovered by R. M. Stewart[1] in 1981 damaging a crop of barley. The other, *M. ardenensis* was found by Dr. P. R. Thomas[2] near Cupar, Fife, and a study has been made of its life style cycle on a hedge of *Lonicera nitida*. This study has shown that the nematode has one generation a year, females in the roots being the main over-wintering stage. These females lay most eggs during the spring and juveniles enter the roots in May and June and become adult in September or October. Studies in temperature controlled facilities have demonstrated that *M. ardenensis* is adapted to Scottish conditions, the optimum temperature range for development being 15-18°C, the nematode failing to develop at temperatures above 20°C and females in roots withstanding −5°C for 1 wk.

(Z. A. Stephan, D. L. Trudgill)

The effect of temperature on the development of another root-knot nematode, *M. hapla*, on tomato and cucumber was also investigated. Four populations, two from the USA, one from Canada and one from England were tested. All populations reproduced on tomato, the lower limits for development being between 16 and 18°C. Cucumber was partially resistant to all the populations, but the degree of resistance was affected by the temperature. One American population produced most egg-masses at 24°C

[1] West of Scotland Agricultural College.
[2] Open University.

and none at 18°C, whereas the other and the English population produced most egg-masses at 18°C and fewest at 24°C. Dissection of the root-knot galls showed that at unfavourable temperatures in cucumber the development of the larvae was retarded, and many partially developed larvae died.

(Z. A. Stephan)

05011 *Migratory plant parasitic nematodes associated with vegetable crops in Scotland*

Effect of pesticides on Rotylenchus robustus and the yield of swede, grass and beetroot

Trials in 1980 and 1981 investigated the effect of a partial soil sterilant — dichloropropene (Telone II) at 225 l/ha applied pre-planting and broadcast applications incorporated at planting of an insecticide — chloropyrifos (Dursban 5G 5% a.i.) at 4.5 kg/ha, a fungicide-benomyl (Benlate 50% a.i.) at 25 kg/ha and a systemic nematicide-aldicarb (Temik 10% a.i.) at 3.3 kg/ha on *R. robustus* populations and the yields of the three crops. The numbers of *R. robustus* were reduced by 98% by dickloropropene, by 72% by aldicarb and by 36% by chloropyfrios compared with the untreated control. The yields of grass and swede were significantly increased in plots treated with dichloropropene and aldicarb respectively. The yield of beetroot was not significantly affected by any of the pesticides but yields of all three crops were significantly increased by the application of fertiliser.

(B. Boag)

Effect of dichloropropene on Rotylenchus robustus *and the growth of young Scots pine trees*

R. robustus is known to damage seedling trees but its effect on 3- and 4-year old trees is unknown. A trial at a site infested with 380 *R. robustus*/200 g soil and smaller numbers of trichodorid nematodes tested the effect of dichloropropene (Telone II, 225 l/ha) on the growth of 2-year old Scots pine trees planted in June, 1980. The dichloropropene decreased the numbers of *R. robustus* in the first year by more than 92% compared with those in the untreated control plots. The growth of the trees was not significantly increased in the first 9 months but by October 1981 trees in the treated plot were significantly taller and heavier than those in the untreated.

(B. Boag)

05003 *Chemical control of virus vector and the other plant parasitic nematodes*

Effectiveness of oxamyl applied to plant foliage for controlling root-feeding nematodes

Oxamyl (Vydate L) is one of the few pesticides which, when applied to plant foliage, is translocated to the root system where it is nematicidal. A

nematicidal root exudate is thought to be produced in the rhizosphere conferring a degree of protection against virus vector and other plant parasitic nematodes. To determine whether oxamyl, or a nematicidal derivative, was exuded from treated plants the leaves of cucumber (*Cucumis sativum*) plants growing in 20 ml of water were treated with oxamyl (4000 ppm) on 4 consecutive days. Great care was taken to ensure that there was no contamination of the water, and on the fifth day it was filtered to remove plant debris, and concentrated by freeze-drying. The resultant residue was resuspended in 2 ml distilled water into which were placed freshly extracted *Xiphinema diversicaudatum* 40% of which protracted their stylets within 10 min of immersion, a similar result to that obtained when *X. diversicaudatum* was treated *in vitro* with oxamyl solutions of more than 10 ppm. In solutions from untreated control plants no stylet protraction occurred indicating protraction was due to nematicide exuded from roots of treated plants.

(T. J. W. Alphey)

The effectiveness of foliar applied oxamyl was thought to be greater against nematodes in the soil than those endoparasitic within the roots, and this has been supported by recent experiments with *Meliodogyne hapla*. Oxamyl applied before tomato plants were inoculated with *M. hapla* juveniles, completely protected plants from infection. Oxamyl sprays applied after infection did not provide complete protection from *M. hapla*, only reducing the rate of development of the juveniles and the numbers of females and egg-masses produced. The greater the delay between infection and treatment, the fewer the number of juveniles that were killed but the more that became male.

(Z. A. Stephan, D. L. Trudgill)

Effect of nematicides on Longidorus elongatus

Studies on the effect of fallowing on the susceptibility of *L. elongatus* to nematicides were continued. Plots previously planted with a ryegrass/clover mixture or fallowed for the previous 6 months were cultivated and treated in the spring with aldicarb (Temik, 3.3 kg a.i./ha), oxamyl (Vydate, 5.6 kg a.i./ha), quintozene (Botrilex, 89.6 kg a.i./ha) or left untreated before being resown with a ryegrass/clover mixture. In the untreated control plots the numbers of *L. elongatus* were similar during the following 80 wk, population changes in previously fallowed or planted plots tending to be similar. All the chemical treatments decreased numbers of *L. elongatus* in comparison to the untreated controls, the most effective treatment being quintozene which rapidly decreased the numbers of *L. elongatus* and prevented their increasing for the duration of the experiment. Numbers of *L. elongatus* in the oxamyl and the aldicarb treated plots were decreased by 60% after 12 wk but control was of short duration and after 18 wk numbers progressively increased. During the experiment there were significantly fewer *L.*

elongatus in the oxamyl/fallow plots than in those which grew grass, a result primarily due to the low rate of reproduction. No other treatment/crop interaction was found and at the end of the experiment (after 80 wk) numbers of *L. elongatus* in the oxamyl/grass and aldicarb treated plots were similar to those in the untreated.

(T. J. W. Alphey)

05007 *Ecology of* Longidorus *and* Xiphinema spp. *in relation to their role as plant pathogens*

Rate of reproduction of L. elongatus *and* X. diversicaudatum *on plants of different host status*

In pots (15 cm) inoculated with groups of 20 females there was a 34-fold increase in the numbers of *L. elongatus* over 146 days at 18°C when strawberry cv. Cambridge Favourite was the host. On turnip cv. Green Top Yellow Dwarf, a poorer host for *L. elongatus*, there was only a sevenfold increase and the life cycle took 146 days compared with 117 days under strawberry. In the same experiment the life cycle of *X. diversicaudatum* took almost 160 days on strawberry and the population increased 31-fold.

In a separate experiment in small pots (25 ml), single females of *L. elongatus* reproduced twice as rapidly under perennial ryegrass (*Lolium perenne*, S24) than under turnip.

(B. S. Griffiths)

Effect of cropping on numbers of L. elongatus *and other plant parasitic nematodes*

The depth distribution of *L. elongatus* was examined at a site where monocultures of six crops had been grown during the previous 4 years. The results showed that *L. elongatus* was more abundant in the top 20 cm (51/200 g) of soil than between 20 and 40 cm (28/200 g) and, although statistically significant differences in numbers occurred with both depth and crop, no significant effect of crop on the vertical distribution of *L. elongatus* was detected. However, the numbers of *L. elongatus* may have been affected by predation, the numbers of *L. elongatus* and other ectoparasitic nematodes being inversely related to the numbers of predatory nematodes.

The degree of aggregation of individuals of different species of plant parasitic nematddes differed. *L. elongatus* and *Paratylenchus microdorus* were highly aggregated, with an index of aggregation (b) of 1.8 whereas *Rotylenchus goodeyi* had a near random distribution with a b value of *ca.* 1.0. The degree of aggregation was not affected by either crop or sampling depth.

(B. Boag, Irene E. Raschkē)

Effect of fertiliser on the growth of grass and populations of plant parasitic nematodes

The effect of a compound fertiliser on the growth of grass and the population dynamics of *L. elongatus* was studied at a site growing a grass/clover mixture. Forty-eight plots received the equivalent of 63.5 kg/ha of a fertiliser (20:10:10) at monthly intervals from April until November 1981 whilst another 48 plots received no fertiliser. During 1981 the numbers of *L. elongatus* increased from 260/200 g soil to 609 in plots receiving fertiliser and to 370/200 g soil in non-fertilised plots. The numbers of *Paratylenchus microdorus* in fertilised plots increased between April and November by 17% whilst their numbers decreased 22% in the non-fertilised plots.

(B. Boag)

The location of plant parasitic nematodes in soil

Only gross studies on the distribution of nematodes within soil are possible with existing techniques. A technique used by the Macaulay Institute for Soil Research for studying soil structure was tested for determining the distribution of nematodes in undisturbed soil. This involved cutting thin sections of soil embedded in a styrene monomer and in such sections the location of *L. elongatus* and *R. robustus* could be determined. The two species were separated by the annulations observed when the cutical was obliquely sectioned, and less frequently when longitudinal sections were produced which allowed the internal structures of the nematodes to be examined.

(B. Boag, L. Robertson[1])

European Plant Parasitic Nematode Survey (EPPNS)

A study of the ecology of virus vector nematodes in Europe has continued under the auspices of the EPPNS. To map the geographical distribution of the nematodes a new general purpose computer mapping program IMENS has been written, which provides base maps and subroutines to convert UTM coordinates of distribution data to base map co-ordinates. The program, written in FORTRAN 77, has powerful file manipulation facilities, extensive character handling facilities and requires little storage space. This program has been used to map the distribution of longidorid and trichodorid nematodes in the Netherlands and will be used to produce national atlases for other European countries participating in the EPPNS.

(T. J. W. Alphey, P. B. Topham[2] and R. Shaw[3])

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[1] Macaulay Institute for Soil Research.
[2] Crops Research Section.
[3] Sheffield City Polytechnic.

Longidorus vineacola *recorded from Scotland*

A soil sample taken by G. Hudson[1] from a grass/white clover sward on Berneray Island was found to contain *L. vineacola* (*ca.* 30/200 g soil). This is the first record of this species from Scotland and the third from the British Isles. Specimens, fixed in T.A.F. and mounted in glycerol, had shorter bodies and significantly longer odontophores than those described from the type locality. *Choanolaimus psammophilis*, a predatory nematode normally found in coastal sub-soil water, was also recorded for the first time in the British Isles from the same sample.

(B. Boag)

Xiphinema israeliae *n.sp. Israel*

During a survey of the geographical distribution of *X. diversicaudatum* a new *Xiphinema* species was found in a citrus orchard at Tel Mond, Israel. The new species, named *Xiphinema israeliae*, belongs to the group of *Xiphinema* which have two complete female genital branches of similar length and structure, devoid of any uterine Z differentiation or spines, and a rounded and digitate tail in the female. Males were common *X. israeliae* may be easily differentiated from other, similar, species by differences in morphometric values and ratios.

(D. J. F. Brown, M. Luc[2], E. Cohn[3])

Xiphinema malawiense *n. sp. from Malawi*

Xiphinema coxi and *X. sahelense* have been reported from Malawi. These two species have previously been reported only from Europe and North America. Therefore, several of the localities in Malawi from which the species were reported to occur were resampled and specimens sent to SCRI for identification. Although longidorid nematodes were present in all the samples, *X. coxi* and *X. sahelense* were absent. However, specimens from the rhizosphere of *Citrus* sp., from Limbe, Malawi, were a new species. This has been named *Xiphinema malawiense* n. sp. and belongs to the group of *Xiphinema* species which have two complete female genital tracts of similar length and structure containing a pseudo Z differentiation and a rounded, digitate, tail. Males were absent. The new species may be readily differentiated from similar species (e.g. *X. coxi*) by differences in morphometric values and ratios.

During this survey a male of *Longidorus pisi* was identified and described from the rhizosphere of sugarcane at Nchalo, Malawi.

(D. J. F. Brown, D. J. Hooper[1], M. Luc[2], V. W. Saka[3])

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[1] Macaulay Institute for Soil Research.
[2] Laboratoire des Vers, M.N.H.N., Paris, France.
[3] Volcani Center, Bet-Dagan, Israel.
[1] Rothamsted Experimental Station, Harpenden, England.
[2] Laboratoire des Vers, M.N.H.N., Paris France.
[3] Bvumbwe Agricultural Research Station, Limbe, Malawi.

05004 *Feeding of* Longidorus *and* Xiphinema *spp. in relation to plant response and virus transmission*

Transmission of isolates of tomato black ring virus by Longidorus attenuatus.

Transmission of strains of tomato black ring virus (TBRV) from England and Germany by an English population of *L. attenuatus* was tested using replicated groups of two and five hand-picked nematodes. In the tests, with *Petunia hybrida* as the source and bait plants, English *L. attenuatus* readily transmitted all the virus strains from England (original type strain, celery yellow vein with and without RNA3, an isolate indistinguishable from lettuce ring spot). In the same tests a strain of TBRV from Germany (potato bouquet) was not transmitted.

When the bait plant was *Chenopodium quinoa* instead of *P. hybrida* the potato bouquet strain and a mild and severe isolate of TBRV from a vineyard in Germany were transmitted, but much less frequently than was an English strain from carrot. These results agree with an earlier report (Ann. Rep. 1980, p. 117) that a population of a nematode may transmit strains of a virus with different effectiveness, but they also indicate that the outcome of transmission tests can be affected by the choice of bait plants.

(D. L. Trudgill, D. J. F. Brown)

Transmission of Carnation ringspot virus

Carnation ringspot virus (CRSV), a virus not related to any nematode transmitted virus, has been reported to be transmitted by *L. elongatus, L. macrosoma* and *X. diversicaudatum* in Germany. Using small groups of hand-picked nematodes and the critical procedures developed at SCRI for testing nematode transmission of viruses, no evidence was obtained of transmission by a Scottish population of *L. elongatus*. Virus was infrequently recovered after 4 wk from bait plant roots in tests where *Gomphrena globosa* source and bait plants were grown concurrently, or consecutively, in small pots (25 ml) containing 35 *L. elongatus* but after 8 wk in tests using larger pots (30 cm diam,) without nematodes systemic infection occurred in four of 11 bait plants grown concurrently with the source plants and three of 11 grown consecutively. These results indicate that CRSV transmission can occur without the aid of nematodes and cast doubt on the claim that it is nematode transmitted.

(D. L. Trudgill, D. J. F. Brown)

Plant response to feeding by X. diversicaudatum *and* L. elongatus

The response of a good host (strawberry cv. Cambridge Favourite) and a poorer host (perennial rye grass, *Lolium perenne*, S24) to feeding by *X. diversicaudatum* was examined. Root tips from agar cultures were sampled after 1, 2 and 4 days feeding, sectioned for microscopic examination and

stained so that their RNA and protein contents could be measured using a scanning micro-densitometer. After 2 days galls were induced in both kinds of plants and these contained enlarged, multi-nucleate cells with enlarged amoeboid nuclei and dense cytoplasm. These cell modifications occurred more rapidly and were more extensive and closer to the root-tip in strawberry than in *L. perenne*. Measurements of RNA and protein contents indicated that in control root tips there was a greater concentration of protein in strawberry (68 $\mu g/mm^3$) than in *L. perenne* (42 $\mu g/mm^3$) and also concentration of RNA was greater in the strawberry (5.4 $\mu g/mm^3$) than in *L. perenne* (1.2 $\mu g/mm^3$). In galls induced by *X. diversicaudatum* the density of protein and RNA increased in strawberry but not in *L. perenne* and the total amounts per root tip increased approximately fivefold in strawberry and threefold in *L. perenne* after 4 days.

Previous results have shown that feeding by *X. diversicaudatum* also increased the DNA content of the nuclei within root tip galls (Ann. Rep. 1980, p. 117). Eight day old galls on *L. perenne* induced by *L. elongatus* showed a similar increase in the DNA content of nuclei with maximal values ranging between 10 and 12C. In 12 day old galls the DNA content of those nuclei which remained was 2 or 4C (haploid or diploid values), similar to those of nuclei in control, unfed-upon root tips.

(B. S. Griffiths, W. M. Robertson)

Oil red 'O' and the lipid content of nematodes

Oil red 'O' stain has been used by several research workers to measure the lipid content of nematodes. However, oil red 'O' stain does not chemically bond with lipids and it was uncertain whether the results obtained were quantitatively reliable. An electrophoretic analysis by Dr. O. Bayliss-High[1] identified cholesteryl oleate as the major lipid component in *L. elongatus* and a model system was devised in which cholesteryl oleate was prepared in a range of concentrations in agar blocks. These blocks were sectioned in a cryostat, stained with oil red 'O' and their absorbance measured on a scanning micro-densitometer. The results showed that the method is quantitative, there being linear relationship between the density of the stain and the concentration of cholesteryl oleate.

(B. S. Griffiths, W. M. Robertson, P. J. Stoward[2])

05005 *Ultrastructure of nematode vectors of plant viruses with reference to their feeding apparatus*

Transmission electron microscopy of thin sections through the anterior head region of *Paralongidorus maximus* has shown that each of the four outer

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[2] Department of Anatomy, University of Dundee.

cephalic sensilla (in subdorsal and subventral positions just anterior to the amphidial openings) has an appendage. The appendage is short (3 x 1 μm) and extends posteriorly in a groove against the body. Specimens of *P. maximus* examined with a scanning electron microscope confirmed the position and shape of the appendages and also revealed a conoid pit set in the base of each. Although small it should be possible for taxonomists using a light microscope to locate these appendages in adult specimens of *P. maximus*.

Carbohydrate histochemistry

Studies have continued on the tissues in *Xiphinema* ssp. which stain with the periodic acid-Schiff (PAS) reaction after fixation in formaldehyde. In sections examined with a light microscope the outer membrane and intermediate layers of the cuticle and the odontostyle were intensely stained. In thin sections for the electron microscope treated with the periodic acid-thiosemicarbazide-silver proteinate (PA-TSC-SP) reaction, similar tissues were stained. The lining of channels which pass through the cuticle were also stained. In similar sections from a moulting nematode the intensity of staining of the new cuticle was much less than the cast cuticle indicating that carbohydrates are amongst the last components to be laid down during the moult.

Some problems were experienced with the PA-TSC-SP staining technique and it was found that the acetic acid used to dissolve the thiosemicarbazide was a major source of dirt when used with copper or gilded copper grids. Only gold grids were unaffected by the acetic acid but these are difficult to obtain and are expensive. However, further investigations showed that the acetic acid was not necessary, the thiosemicarbazide dissolving satisfactorily in distilled water if agitated in an ultrasonic bath. Subsequent filtering or centrifugation gave clear solutions and a fine staining reaction without dirt being deposited on the sections.

(W. M. Robertson)

05012 *Ecology and control of* Pratylenchus *spp. associated with soft fruit*

Previous results indicate that nematodes (mainly *Pratylenchus penetrans*) and unidentified fungi are a cause of replant problems in raspberry. This year the tolerance of nine raspberry cultivars and of Tayberry to replant problems was compared in a soil known to contain both pathogens. As an indicator of the amount of damage being caused by each pathogen the growth response was measured following treatment with a nematicide (aldicarb) and a fungicide (benomyl). All the cultivars tested responded to the chemical treatments; the response being much greater to benomyl than

aldicarb. The cultivars Malling Jewel and Malling Promise grew least well in the untreated soil with a mean plant weight of 5.2 and 0.4 g respectively and their growth increased in soil treated with both chemicals, producing mean plant weight 25.3 and 24.0 g respectively. Glen Clova, Tayberry and clone 10-204 grew the largest in untreated soil at 12.9, 15.0 and 14.3 g respectively, and their growth was increased least by the combined chemical treatment at 22.3, 25.8 and 24.1 g respectively. The cultivars Leo, Lloyd George and Malling Admiral and selections of M-30 and 30-54 were intermediate in their response.

The effect of pre-treatment with the partial soil sterilant chemicals dazomet (Basamid) or dichloropropene (Telone II) was also tested using the same field soil. In soil not pre-treated with either chemical the growth of raspberry Glen Clova in pots greatly increased following treatment with aldicarb and benomyl from a mean weight of 3.8 g for the untreated to 22.5 g for the treated. Pre-treatment with dazomet largely removed the response to the combined chemical treatment with a mean plant weight 24.5 g for the untreated and 27.7 g for the combined treatment. In contrast, pre-treatment with dichloropropene had little effect on the growth of raspberry in soil receiving no further treatment (mean weight 4.7 g) and the combined aldicarb/benomyl treatment greatly increased final plant weight (23.7 g).

(D. L. Trudgill)

ENTOMOLOGY

05001 *Ecology and control of horticultural and agricultural pests*

Air assisted spraying

A low velocity medium volume air-assisted sprayer, and a hydraulic sprayer delivering 2000 l/ha gave comparable control of the large raspberry aphid (*Amphorophora idaei*) in 1980 (Ann. Rep. 1980, p.121). In 1981 the air-assisted sprayer, modified by mounting the spray nozzles closer to the fan and by increasing the air speed from 11.3 to 12.9 m/sec, was used to apply three rates of fenitrothion, a contact insecticide, at 0.15, 0.35 and 0.55 l a.i./ha in 350 l of water/ha. Compared with the untreated, numbers of *A. idaei* were decreased by 36, 73 and 87% respectively. A conventional hydraulic sprayer applying fenitrothion (0.55 l a.i./ha) in 2000 l water/ha decreased the numbers of *A. idaei* by 91%. These results indicate that air-assisted spraying can considerably reduce costs by decreasing the volume of spray necessary to achieve adequate control even when spraying against a "difficult" target such as *A. idaei* which colonises the undersides of leaves.

(S. C. Gordon, B. Williamson[1])

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[1] Mycology Section.

05013 *Control of aphids and virus diseases of potato, raspberry and bulbous ornamentals*

Potato

In 1979 trials were started in several areas of Scotland to compare the effectiveness of granular insecticides and early haulm destruction in preventing the spread of potato leafroll virus (PLRV) (Ann. Rep. 1980, p.119). In 1980 there were three new trials, in Banff, Fife and Ayrshire. At each site three large plots (minimum 0.12 ha) of FS1 cv. Maris Piper were planted with four groups of PLRV-infected plants. The centre plot was untreated; the other plots received either ethiofencarb (7.5% a.i., 118 g/100 m) or thiofanox (5% a.i., 112 g/100 m) in-furrow at planting. Half of each plot was burned down in the second or third week in August and the other half 3 weeks later.

After a mild winter the plots were colonised by *Myzus persicae* earlier than in 1979 but aphid populations remained small at each site. The maximum populations of *Macrosiphum euphorbiae* developed earlier than in 1979 and were larger than those sampled in 1979, except in the trial in Fife where they never reached the 1979 level. Both insecticides almost completely controlled *M. persicae* and *M. euphorbiae* until mid-July but thiofanox was slightly more effective than ethiofencarb at all sites.

Tuber samples harvested from these sites were grown at SCRI in 1981 to assess PLRV infection. On untreated plots infection levels in Banff and Ayrshire were similar to those recorded the previous year, but in Fife spread of PLRV was twice as great in 1980. Thiofanox gave almost complete control of virus infection but ethiofencarb was less effective at each site. In Fife and Ayrshire more tubers were infected with PLRV in ethiofencarb treated plots burned down in September than when burned down 3 weeks earlier. On untreated plots early haulm destruction decreased virus spread in Banff and Fife but not in Ayrshire.

(S. C. Gordon, M. W. Shaw[1], R. G. McKinlay[2], P. Osborne[2] G. N. Foster[3])

A problem involved in interpreting the results of all our recent field experiments to control the spread of PLRV is that infector plants have been left in crops throughout the growing season and not rogued in June/July as with commercial seed crops. In 1980 an attempt was made to estimate the effectiveness of aphid control and early haulm destruction in plots where infected plots were removed early in the season. Four treatments were compared: thiofanox (5% a.i., 117 g/100 m) applied in-furrow at planting on 8 April; a spray of pirimicarb (50% a.i., 280 g/500 l/ha) on 21 July; a

[1] North of Scotland College of Agriculture.
[2] East of Scotland College of Agriculture.
[3] West of Scotland Agricultural College.

combination of thiofanox granules followed by pirimicarb spray; and an untreated control. Each plot was split for a haulm destruction treatment on 12 or 29 August.

The experiment was done on the crops grown at SCRI in 1980 from tubers harvested to assess the spread of PLRV in the 1979 SCRI-Scottish Colleges trials. The number of infected plants in each 1980 plot was, therefore, unknown when the 1980 treatments were assigned and roguing had to be slightly delayed, until 5 July, to ensure that all the initial infections were properly recorded. Plots not treated with thiofanox were colonised by *M. euphorbiae* in early June and a few *M. persicae* were detected in mid-June. Although the number of *M. persicae* did not increase greatly very large populations of *M. euphorbiae* developed on untreated plots, reaching maximum numbers in mid-July and causing noticeable 'top roll' damage. By mid-July smaller populations of *M. euphorbiae* were also reproducing on plots treated with thiofanox. Three weeks after the second haulm destruction plants were harvested in the central four rows of each plot; three daughter tubers were sampled from each plant and grown in 1981 to assess PLRV spread.

Roguing completely eliminated leaf roll in two of the 10 untreated plots but did not prevent spread in most untreated plots where the final proportion of infected tubers was similar to the proportion before roguing. Spread was not decreased by the insecticide spray on 21 July or by early haulm destruction on 12 August. These results suggest that PLRV spread early in 1980.

From the estimates of aphid colonisation it is likely that infected plants in some plots were colonised before roguing and some infective aphids may have been disloged during roguing. Thiofanox prevented aphid colonisation before roguing and, overall, reduced the spread of PLRV from 3·34% final tuber infection in plots without thiofanox to 0·96% in plots where thiofanox had been applied. This difference was significant but it was difficult to quantify the effectiveness of thiofanox in this experiment because the response to its use differed significantly between blocks, but was not related in a simple manner to the initial infection levels in the plots.

(S. C. Gordon, J. A. T. Woodford)

Thiofanox granules applied at planting have consistently controlled aphids and the spread of PLRV in most field trials in Scotland. The main reason for the effectiveness of thiofanox is that potential vectors are unable to survive and breed on PLRV-infected plants which have been treated with thiofanox. Research elsewhere has shown that insecticides are unlikely to act quickly enough to prevent aphids which are already infected from transmitting PLRV. In a small field experiment at SCRI in 1980 groups of *M. persicae* infected with PLRV were caged on FS1 Maris Piper for 8 days on two occasions starting on 4 and 24 June. Single leaflets on six plants treated with

thiofanox (5% a.i. 112 g/100 m) at planting, or untreated, were caged with 15 *M. persicae* on each occasion. Tests with *Physalis floridana* confirmed that the aphids were infective. At the end of the exposure period the aphids were killed by spraying with pirimicarb. Six tubers were harvested from each plant and grown in 1981 to assess PLRV infection.

Five of the six untreated plants inoculated on 4 June were infected and all the tubers harvested from these five plants were infected. Three of the treated plants inoculated on 4 June were also infected and in these plants tuber infection was almost 100%. All the untreated plants inoculated on 24 June were infected but tuber infection (61%) was less. On this occasion five of the plants treated with thiofanox and 50% of the tubers were infected. Samples of tubers from uninoculated plants showed there was almost no background spread of PLRV in this experiment.

(S. C. Gordon)

ESTATE

W. I. A. JACK

A review of the functions and objectives of the Section in relation to the use of Institute land and glasshouse facilities at Mylnefield was initiated to ensure that the requirements for field trialling and glasshouse services can be satisfied as the additional demand is transferred from Pentlandfield. The review took account of land use at Mylnefield, Gourdie and Ninewells farms, and packages of land *ca.* 10 ha in area have been designated, and rotations started, to prepare land for field trial purposes.

High costs demand efficient farming, and the difficulties for management are many. With many problems, the factors that have to be considered are extremely variable and none more so than the weather. Keeping crops free of weeds, pests and diseases is a major undertaking, and the weather can prevent timeliness of chemical applications and consequently have a lasting effect on crop quality and yield.

Farm and experimental crops

Farm crops included 38.5 ha barley, 8.5 ha winter wheat, 3.2 ha hay, 1.5 ha grass, 1.6 ha field beans and 0.8 ha fallow; this was a decrease of 5.2 ha from the previous year as more land was required for experimental crops, in particular cereals and potatoes.

Barley sowing started on 27 February, more than a month earlier than the previous year; it was then frequently interrupted by rain throughout March and was finally completed on 10 April. Despite the weather conditions, seedbeds were generally good and the combination of the use of the combine seed drill and high grade seed corn produced a good plant stand.

Although the crop was slightly damaged by frost between 23-25 April, it recovered well. An outbreak of mildew (*Erysiphe graminis*) on all fields in late May required a fungicide to be applied. Harvesting started on 5 August and was completed under favourable conditions on 21 August. The yield of 6.0 t/ha was up 0.3 t/ha on the previous year, with grain samples being of good quality, and with a moisture content averaging 18.8%; the nitrogen content was such that 93% was sold for malting.

Winter wheat cv. Mardler, sown in the autumn of 1980, overwintered well. Experience shows that growing with higher levels of inputs results in

higher yields and better financial returns. This year several tried techniques were employed to try to achieve a 10 t/ha crop, including establishment of an accurate plant population, the selective application of nitrogen, and pest and disease control. Combining started on 26 August, and the crop yielded 9.22 t/ha, an increase of 1.78 t/ha on 1980.

Grass never recovered from the April frost and dryish April and May. The crop was cut for hay on 12 June; baling was completed on 21 June and, although a light crop, it was of good quality. A second cut was taken on 30 July and was baled and carted in excellent conditions.

Field beans, cv. Maris Bead, were sown on 25 February into a perfect seedbed; after a slow establishment they grew well with little evidence of pests and diseases being present. No desiccant was applied and they were combined on 16 September. Although the size of bean was much smaller than the previous year the yield was up 1.4 t/ha.

Field experiments included 11.8 ha raspberries, 6.4 ha black currants, 6.2 ha potatoes, 3.3 ha brassicas, 1.9 ha black and hybrid berries, 1.9 strawberries, and 4.5 ha other crops.

The picking of soft fruit commenced with strawberries on 26 June, 13 days later than 1980, followed by raspberries on 6 July, black currants on 7 July, Tayberries on 17 July, other hybrid berries on 27 July and blackberries and blueberries on 8 August. The weather was excellent throughout the fruit season, with the exception of 22 July and 3 August when rain stopped picking. Losses through April frosts were severe, in particular in the raspberry crop, but *Botrytis* was negligible. Although on the small side, the quality of fruit was generally high.

The fruit crops sold included 23.8 t raspberries, 16.1 t strawberries, 2.1 t black currants, 0.4 t blackberries and 0.1 t of other fruits. This totalled 7.7 t less than 1980. Marketable produce from vegetable trials totalled 6.2 t, showing a decrease of 37.3 t over 1980 due to frost and pigeon damage during the extreme weather in December.

The potato crop suffered greatly from drought conditions during July and August. Lifting started under good conditions on 14 September but conditions deteriorated thereafter, and severe frost on 25 October resulted in tuber damage to the unlifted crop. Lifting was finally completed on 5 November. The yield of 24.7 t/ha was a decrease of 21 t/ha on 1980.

Field work was greatly affected by the weather in the last 4 months of the year. Stubble was cleaned by spraying glyphosate (Roundup). Ploughing was carried out when conditions allowed, and mostly was completed by the time of the freeze-up in early December. The spell of bad weather persisted throughout December, stopping all land work, so labour resources were directed to Gourdie farm for the removal of old dykes and the levelling of banks in preparation for the erection of a vermin-proof fence on the south boundary of the farm.

New farm equipment acquired during the year included a rough terrain fork lift truck, a set of dual wheels, a chain saw, and sprayer controls.

Glasshouses

Glasshouse accommodation was reduced by the removal of 276 m^2 of heated glass to allow site clearance for the erection of the new plant breeding range. The sight of new glass under construction provided encouragement despite the disruption caused to the day-to-day running of the unit.

Plant production at 111,818 units was 15,446 down on 1980; included were *ca.* 59,000 test plants for the Virology and Zoology sections. Black currant plants raised totalled 12,800 and ESCA were supplied with 1,000 softwood cuttings; 3,500 virus-free bulbs propagated by twin-scaling were planted out in an insect-free Tygan structure, and several sowings produced plants for field trials of brassicas and raspberries.

Pest and disease control gave few problems following prompt and regular control measures; however, it was noticed that red spider was rather persistent despite frequent control measures with different chemicals.

Investigations have been initiated on soil-less compost mixtures and Vitax Q.-4, a slow release fertiliser, in an attempt to produce a compost to give speedy initial growth with long term nutrient availability.

New equipment purchased during the year included a soil mixer and a Filclair Tygan structure.

INFORMATION SERVICES

R. J. A. EXLEY

For many years Mylnefield has regularly provided displays at premier horticultural shows and trade events throughout the country. However, during the year the Ayr Flower Show provided the occasion for the first joint Mylnefield/Pentlandfield exhibit and the first opportunity for collaboration in this field.

Such displays are always subjected to searching appraisal by audiences with a wide spectra of technical background. Although the design team may have confidence in the appropriateness of the subject matter and the excellence of text and illustrative work, only those at the interface with the audience can judge the relative success in putting the message across. However, the Institute's displays are always well received, a fact that is due in part to the policy of continuing participation which creates the confidence of familiarity and thereby an aptitude for matching the displays to the venue. Although not strangers to agricultural events, we look forward to the challenge to be provided by different crops at new venues.

LIBRARY

The library at Mylnefield holds about 1750 books, and nearly 500 periodicals of which about 230 are currently subscribed to. There are also numerous series of reports, Annual Reports, and reprints.

During 1981 we handled 705 loans from our own stock and 1334 inter-library loans. This represents an increase of 26% from 1980, all of which is accounted for by inter-library loans. These figures do not take into account the periodical circulation system, by means of which staff see the current issues.

During the year there were 17 literature searches on a variety of subjects, and 130 items were purchased for the stock including 41 books. Thirty six translations or partial translations were arranged on behalf of various members of staff.

Both members of the library staff attended the National Library of Scotland Inter-library Loans Seminar in Edinburgh in October, and the librarian attended both meetings of the Scottish Agricultural Libraries Group.

(Urusula M. McKean)

Monochrome photography production was the highest on record; increases in prints for publication and a new requirement of processing and printing films exposed in the Scanning Electron Microscope contributed to the overall figures.

Photography				Graphics		
	Jobs	Colour	Monochrome	Diazo	E.M./Prints	Jobs
1980	1608	4533	4722	579	2902	92
1981	1613	4191	6544	486	2056	76*

*For an 8 month period.

Six aerial photography sorties were flown during the year in the months of June, August and September. This technique has proved to be an excellent tool for recording patterns of crop growth not normally seen from the ground and because of the use of local light aircraft is cost effective.

Time-lapse photography was used to record the effect of a nematicide and a fungicide on the root and top growth of raspberry cv. Glen Clova; exposures were taken for a period of 44 days with a time interval of 15 minutes. A new technique was devised to illustrate the tracks made by the movement of nematodes after chemical treatment on agar plates. Instead of photographing the plates onto film, monochrome enlargements were produced using the plates as the negative; the results gave better detail and contrast than was possible by the conventional method.

Other specialised projects undertaken were high speed cine to assess the movement of raspberry leaves in the airflow generated by a cross-flow sprayer, ultra-violet photography in short and long wave-lengths to identify bands on silica TLC plates following chromatography, and to visualise pollen germination and tube growth.

In April the Section was host to the Scottish Conference of the Institute of Medical and Biological Illustration when over 40 delegates attended a very interesting and varied programme within our specialised sphere of photography.

(T. G. Geoghegan)

RESEARCH REPORT
PENTLANDFIELD

AGRONOMY DIVISION

F. J. W. ENGLAND

The Agronomy Division provides farm and glasshouse services at Pentlandfield and the Murrays farm. The Division also includes the Field Trials Unit and the Statistics and Computing Unit.

The Field Trials Unit carries out trials of breeders' advanced material of cereals and brassicas and also conducts trials for sister institutes and other bodies. Much of the work is carried out at 'off-station' sites. Accounts based on data acquired by the Unit appear in the report of the appropriate client department.

The Statistics and Computing Unit was augmented in April by the appointment of Mr. R. Kidger to specialise in providing computer services, leaving Mr. McNicol more time for statistical consultancy. During the year the micro-computer based data capture and processing scheme, as originally envisaged, was virtually completed although there are many possibilities for future development.

FIELD TRIALS UNIT

The Field Trials Unit handled 41 spring and winter cereal trials and 14 brassica trials. The trials were grown at the Murrays farm, Mylnefield and eight other sites. Spring cereal trials were drilled in late March, considerably earlier than in the past two seasons. Yellow rust was particularly severe especially in the winter barley. The trials were combined, starting with the winter barley plots in early August and finishing with the winter wheats in mid-September.

The kale and swede trials were drilled in mid-May, followed by the rapes in June. Mildew *(Erysiphe cruciferarum)* reached quite high levels in the susceptible selections. The extremely inclement autumn weather made conditions at harvest particularly difficult and most of the trials at the regional centres were hand harvested.

The winter trials were drilled in October. Surprisingly, there was a good braird despite the very wet weather in early winter. Five spring barley candidates, one kale and one swede candidates have been submitted to official trials for Plant Variety Rights, following 2 years of performance trials carried out by the unit.

(I. M. Chapman, A. Young)

MURRAYS FARM

The weather in 1981 was about average except in two respects; August, which is usually the wettest month, was the driest and October the wettest; nearly half of that month's rain (58.7 mm out of a total of 125.5 mm) fell in the first 24 hours of the month.

Ploughing, held up by the wet autumn of 1980, was finished on 29 January and about 11 ha spring barley were sown in mid-March. Wet weather prevented further sowing until the end of the month and sowing was not completed until 14 April. A total of 42.5 ha was sown, all cv. Golden Promise, treated with a mildew fungicide. Grain fertiliser (22:11:11) at the rate of 375 kg/ha was applied to the seed bed. Growth was good and disease levels were minimal although, at the end of June, fenpropimorph (Mistral) fungicide was sprayed by helicopter on Loan and Longriggs fields because of the development of mildew. Harvesting started on 24 August and finished on 10 September. Yields averaged 5.40 t/ha and varied from 4.91 to 5.74 t/ha. The grain was all sold for malting and a sample won third prize for malting barley at the Scottish Agricultural Winter Fair in December.

The 25 ha of winter wheat cv. Mardler overwintered well and was top-dressed with grain fertiliser (22:11:11) at the rate of 375 kg/ha in March. The crop in Cottage field was disppointing but in Toll and Reserve C fields the crop was good. Harvesting was completed on 30 September. The mean yield was 6.14 t/ha.

In Sunnyside, Potato Shed and Reserve A fields a total of 19.6 ha were used for cereal trials and selection plots.

Potato trials were grown in Crow field and occupied about 10.0 ha. In February, fertiliser (0:21:21) was broadcast on the furrow at the rate of 500 kg/ha and potato fertiliser (15:15:19) was applied on the flat before ridging. The early potato trial was planted on 6 April; maincrop planting started on 17 april and finished on 30 April. Thiofanox (Decamox) granules were applied in the drills before covering. All potatoes were sprayed with metribuzin (Sencorex) 3 weeks after planting. In addition, a second spray of metribuzin at half rate was applied to maincrop potatoes at the end of May. Weed control in the area given this second spray was much more effective than in the area given only the single application.

Some of the early potato plots were harvested at the end of June. From July the crop was sprayed weekly with an aphicide, alternately demephon or demeton-S-methyl and pirimicarb. Two sprays in July and one at the end of August included a fungicide.

At the beginning of September the tops were pulverised and sprayed with metoxuron (Deftor). Harvesting started on 10 September and finished on 8 October. Yields were satisfactory. The ground has been grubbed at regular intervals since the end of harvest in an effort to kill off groundkeepers.

Brassica trials occupied about 7.5 ha in Wee Murrays and Potato Shed fields and, in addition, a direct drilled kale trial was sown in Reserve B field. The area in Wee Murrays field was divided between swedes and leafy

brassicas. Muriate of potash (50%) was applied in February at the rate of 188 kg/ha. At the end of April potato fertiliser (15:15:19) at the rate of 850 kg/ha was applied on the area for swedes and grain fertiliser (22:11:11) at the same rate was applied for kale and rape. Trifluralin plus napropamide (Neepex) for swedes and trifluralin (Treflan) for leafy brassicas was incorporated in the soil before sowing. Sowing started at the beginning of May and continued at intervals until the end of June. The crop was sprayed twice with chlorphyrifos (Dursban 48E), immediately after sowing and 3 weeks later. Despite this treatment, some damage was caused by cabbage root fly. On the whole growth was good but clubroot affected some trials. Harvesting started on 12 October.

Folly and Wall fields were direct sown to grass in the spring and were grazed by lambs from East of Scotland College of Agriculture. Reserve B field received 250 kg/ha of (20:10:10) in mid-February and 375 kg/ha of (0:21:21) at the rate of 375 kg/ha in mid-March. It was cut at the end of June and yielded 7.66 t/ha of good quality hay which was sold to ESCA. The aftermath received fertiliser (20:10:10) at the rate of 250 kg/ha on 8 July and was afterwards grazed by sheep.

Longriggs and Reserve C fields were ploughed and drilled with winter wheat cv. Mardler at the end of October. Fertiliser (8:20:16) at the rate of 375 kg/ha was applied to the seed bed. Early growth was good. Sunnyside field was ploughed and drilled, also with Mardler winter wheat, in the first week of November. Owing to adverse weather conditions it was not possible to apply fertiliser to the seed bed but the crop began growing satisfactorily.

Winter cereal trials were sown at the end of September in the north end of Wee Murrays field. There was a good braird and growth was good during the autumn. The severe weather of December should provide a test of winter hardiness.

At the end of the year gales caused damage to roofs in the old steading and this was repaired; otherwise weather conditions did not pose many problems. The drainage worked well on the whole although one or two problem areas are being investigated.

(G. R. White)

CHEMISTRY DIVISION

M. J. ALLISON

During the year a capillary gas chromatograph was acquired and has been used for qualitative and quantitative analyses of potato glycoalkaloids, as a valuable backup to the dye-binding method currently used in the laboratory to estimate the glycoalkaloid content of potato breeding material. Capillary gas chromatographs can also be used as amino acid analysers and thus to detect disturbances in the amino acid balance in kale lines selected for a low content of S-methyl cysteine sulphoxide (SMCO — an amino acid derivative that can cause haemolytic anaemia in ruminants). In addition the total glucosinolate content of brassicas can be estimated and individual glucosinolates identified on capillary chromatograms.

During the year the Neotec 6350 scanning infra red analyser was calibrated for the prediction of counts of spores of the barley diseases, mildew, yellow rust and brown rust. Spores are washed from infected leaves, dried on to paper discs which are then scanned in the Neotec and the spore count is predicted rapidly (less than 1 minute per sample) using one robust prediction equation in which only the constants have to be changed when spores from a different disease are scanned. High correlations ($r>0.9$) have been obtained between infra red (NIR) predicted and manual spore counts.

An NIR prediction equation was also successfully used to estimate the SMCO content of cv. Maris Kestrel leaves ($r\simeq0.9$ for NIR predicted and manual values). Furthermore these high correlations were independent of the correlation between nitrogen and SMCO, and these two tend to be highly correlated in leafy material. In contrast the prediction of SMCO in stems and whole plants was less successful ($r<0.85$) and depended strongly on the correlation between SMCO and nitrogen. When the latter correlation coefficient for a large number of samples fell below 0.6, the NIR predicted versus manual correlation coefficient fell below 0.7.

Some promising results were obtained for the prediction of kale digestibility by a robust multiple regression NIR equation with three terms. In addition NIR scans of cell wall constituents revealed that certain constituents absorbed at wavelengths used in the prediction equation. Collaborative work with other institutes and commercial companies has aided progress towards the derivation of a robust NIR equation for the prediction of malting quality.

The Technicon 300 fixed filter infra red analyser was calibrated for the prediction of soluble beta glucan in barley and this machine was also calibrated using a Technicon equation for the prediction of barley nitrogen.

Routine chemical analyses undertaken included estimations of glycoalkaloid content of potatoes (139 samples); Kjedahl nitrogen (1,900 barley and brassica samples); estimations of ∝-amylase and diastatic activity (700 barley samples); manual predictive method for diastatic activity (900 barley samples); estimations of digestibility (850 brassica samples); estimations of S-methyl cysteine sulphoxide (2,000 brassica samples); estimations of thiocyanate content (1,000 brassica samples) and estimations of vitamin C in potatoes (70 samples).

Progress was made in building an automated micro-malting apparatus and the new unit should be ready for testing early next year. The Chemistry Division's Apple microcomputer was incorporated into the data processing aspect of our digestibility analysis, and it is hoped that eventually nearly all of our data processing for routine work will be controlled by the microcomputer.

07002 *Brassicas: Develop and apply screening tests for useful and harmful biochemical components in brassicas and related spp*

S-methyl cysteine sulphoxide (SMCO)

This amino acid derivative, which can cause haemolytic anaemia in ruminants, was estimated again this year in the kale breeding material and as a part of a time course study on the build-up of SMCO in leaves, petioles and stems of cv. Maris Kestrel during growth. Although an automated method is used to measure SMCO, the column separation in the system restricts sample throughput to 150 per week. Some success in estimating SMCO more rapidly has been achieved using infra red prediction equations, but high correlations ($r \simeq 0.9$) have been obtained only for predicted versus manual values of SMCO content in leaves. Attempts to predict SMCO in stems and whole plants using NIR were unsuccessful.

Thiocyanates

As for SMCO, thiocyanate estimations were made both in breeding material and as part of a time course study on changes in toxic factors during plant development. It was observed again this year that thiocyanate production was uniformly low in the forage rape breeding material and it seems likely that the main goitrogens in rape are due to glucosinolates, other than the indoleglucosinolates that yield thiocyanate ions as breakdown products.

For this reason some development work on a new automated method for measuring total glucosinolates was initiated. The new method looks promising and is capable of a high sample throughput. Experiments are in progress to compare results from the new method with results from the more

standard, slower methods. The majority of this year's work consisted of automated determinations of SMCO, thiocyanates and nitrogen in brassicas and diastase, alpha amalyse and nitrogen for the barley breeding programme.

(R. Borzucki)

07011 *Brassicas: Breed kale and fodder cabbage cultivars*

Estimates of digestibility of kales

Of 880 samples analysed for digestibility, 200 samples were analysed in duplicate to provide a population for infra red analysis. Because brassica nitrogen has been successfully estimated using NIR and there are also promising results from NIR predictions of SMCO it seemed worthwhile to include digestibility in the NIR work. Not only is the estimation of digestibility a lengthy procedure, but if prediction is successful then the different quality parameters could be estimated simultaneously on the same sample.

A predictive equation utilising three wavelengths was derived from a calibration population which consisted of kale polycross material plus standard kale cultivers. The equation proved to be successful in screening for lines with high digestibility from different years and different sites.

As part of this investigation spectral scans were taken of chemical constituents of cell walls with the aim of matching areas of absorption with the wavelengths chosen for the prediction equation. It was observed that ferulic acid, a component of lignin, absorbed at the same two wavelengths that were chosen as the best prediction of digestibility. Arabinose also absorbed at one of the wavelengths in the equation, whereas the spectral absorption of xylose, glucose or pectin did not coincide with any of the equation wavelengths. This is an indication that hemicellulose, and specifically the arabinose groups in hemicellulose, may limit the digestibility of kales. Some more indirect evidence from spectral scans of pure chemicals indicated that acetyl groups may also play a role in restricting digestibility.

The efficiency of processing the data on digestibility was improved when programmes written for the Chemistry Apple microcomputer allowed all weights to be logged and calculations of organic matter percentage etc. to be made by the microcomputer.

(M. J. Allison, J. G. McCluskey)

08007 *Study mechanisms of partial resistance of oats and barley to* Erysiphe *and their use in resistance breeding*

Estimating spore production by fungal pathogens using near infra red reflectance analysis (NIR)

Work continued on an NIR method for counting spores of foliar pathogens of barley. Three infra red frequencies (1900 nm, 2252 nm and 2308 nm) were

identified where the absorptions could be related to spore numbers of powdery mildew *(Erysiphe graminis* f.sp. *hordei)*, yellow rust *(Puccinia striiformis)* and brown rust *(Puccinia hordei)* of barley as well as brown rust of wheat *(P. recondita)*.

For all populations examined, correlations between the number of spores predicted by NIR and the number counted using a haemocytometer slide were very high ($r>0.9$). Over the range $0\text{-}30 \times 10^3$ spores, the standard errors associated with the predictions were low and there was evidence to suggest that the major errors were associated with the direct counting method.

Requirements for the success of the technique include the need to collect spores from leaves in a dry condition to avoid the inclusion of leaf exudates in the sample, and the need to dry spores prior to scanning. Each sample can then be counted in less than 30 seconds, and the results stored on computer disk for further analysis.

Work continues on the adaptation of this technique to simple fixed filter instruments for the routine analysis of spore samples. It is hoped that this technique will eventually provide a reproducible method of rapidly counting large numbers of spore samples, and will thus be useful in the assessment of certain types of disease resistance.

(M. J. C. Asher[1], I. A. Cowe, D. C. Cuthbertson, Clare E. Thomas[1])

08009 *Barley: Study biochemical components of barley and oat grains related to malting, feeding and processing quality*

It has been reported that certain electrophoretic patterns of the hordein storage proteins in barley relate to malting quality. It has also been shown that a locus for hordein B-type protein bands is closely linked to major gene locii for mildew resistance. Because of the current interest in the hordeins, separations of them using polyacrylamide gel electrophoresis were made during the year. The C and B hordeins differed between cultivars and a further attempt will be made to link pattern to malting quality and to other prediction tests, e.g. milling energy, for malting quality.

Electrophoretic separations of leaf barley soluble proteins showed much less variation than the seed soluble proteins. Investigations of the leaf proteins, however, have been confined so far to the salt soluble proteins.

(M. J. Allison, M. Christine Mackay)

08010 *Develop and automate small scale tests for malting, distilling, breeding and milling quality*

Assessment of malting quality of barley cultivars by a micromalting analysis

This year 665 samples were micromalted and subjected to full malt analyses. The results for a number of samples were atypical in that high hot water

[1] Forage Division

extract values were observed when grain nitrogen estimates were also high. However, the ranking of breeding lines and cultivars in order of malting quality in joint trials compared very well with the ranking orders of similar material analysed in other laboratories. It has been agreed with the barley breeders that there should be a more rigorous selection of samples to be micromalted, e.g. high nitrogen samples (over 1.9%) should not be micromalted.

A start was made in building an improved automated micromalting system based on the Seeger micromalting unit and this will be completed soon. It is intended to micromalt samples in parallel on the old and new systems for at least one season.

Progress has been made during the year towards the derivation of an infra red calibration equation for the prediction of hot water extracts of malted barleys. As a result of collaborative work with other institutes and commercial companies a predicitive equation has been derived and this will be rigorously tested on micromalted samples.

(Frances M. Bruce, I. A. Cowe, D. C Cuthbertson)

09001 *Potatoes: Breed maincrop potato cultivars for quality, disease resistance and yield for fresh use and for processing*

Estimation of glycoalkaloid content of maincrop breeding material

Early in the year a collaborative experiment between this laboratory, FRI, Norwich and NIAB, Cambridge, showed that there was fairly good agreement concerning estimates made of the glycoalkaloid content (TGA) of a few samples that varied widely in TGA content, (the dye-binding method developed at FRI was used by all three institutes). In October this dye-binding method was used to estimate the TGA content of 109 maincrop genotypes derived from crosses using *S. vernei* as a source of eelworm resistance. This analysis has not yet been completed, but results so far show that the lines range widely in TGA content (5 to 70 mg TGA per 100g fresh weight). Extracts of some of the samples were separated on a capillary gas chromatograph and it was established for these samples, at least, that solanidine was the main product from acid hydrolyses.

(M. Christine Mackay)

FORAGE DIVISION

R. N. H. WHITEHOUSE

The work of the Forage Division is geared to the primary objective of producing cereal and forage brassica cultivars of agricultural worth. The programme has been amended with the result that independent work with oats is being phased out leaving barley as the only major cereal crop, although co-operaion was (and will continue to be) given to winter wheat and spring oat breeding at the Plant Breeding Institute and Welsh Plant Breeding Station respectively. This co-operation is largely through the trials conducted by the Agronomy Division but discussions concerning Scottish requirements also occur more widely with Institute staff. There is also a co-operative breeding programme with PBI for field beans *(Vicia faba)* in which crosses made between material introduced at SCRI and PBI breeding lines are being selected at Pentlandfield.

Amongst the forage brassicas attention has been given principally to swedes, forage rape and kales. Less effort is now devoted to fodder cabbage, turnips and radish while the work with radicole has been redirected towards a study of some fundamental short-comings of the crop. If these can be solved the way will then be clear to resume breeding. There are no co-operative programmes comparable to those with cereals because the Institute has a national responsibility for forage brassica breeding which has now ceased (apart from stock maintenance) at other Agricultural Research Service Institutes.

A further change in the programme has been the extension of the work of the Unit for Strategic Brassica Breeding to include a range of *in vitro* culture techniques. Previously the Unit was concerned with the production of breeding material from difficult inter-specific and inter-generic crosses in order to widen the genetic base available to the breeders. This necessitated the use of embryo culture and chromosome doubling. Now, however, the techniques of callus culture and the production of ex-plants from leaves, stems, anthers, ovaries and apices are being developed or modified to suit particular species with a view, initially, to serving the brassica workers at SCRI but, ultimately, for the benefit of other crop programmes. There is no immediate intention of culturing protoplasts but progress elsewhere is being monitored.

All the main breeding programmes, with the exception of that with winter barley which is of recent origin, are at a stage at which selections can be

submitted for National List Trials (NLT). As a result of official and SCRI trials in 1981 with spring barley, two cultivars (Tay and Tweed) will move into Scottish Recommended List Trials, three (Almond, Don and Leith) will enter second year, and five will enter first year NLT. Correspondingly, amongst the forage brassicas two swede cultivars (Angus and Melfort) are in Recommended List Trials, two swedes, one forage rape, and one fodder radish,cv. Crail, have entered second year NLT, while one swede and one winter kale will enter first year NLT in 1982.

Studies of pest and disease resistance have shown that partial resistance to powdery mildew *(Erysiphe graminis)* is available amongst barley cultivars at levels which delay the development of epidemics and might be used in commercial breeding. Some of these types of resistance have been found to operate via different mechanisms at the cellular level which suggests that it may be possible to combine them to provide greater resistance.

The resistance of Angus and Melfort to turnip root fly, which has been shown in College trials in the west and north of Scotland, provides a character, not previously available to swede growers, which is especially important where bulbs are being produced for domestic use. New sources of resistance to club root (caused by *Plasmodiophora brassicae*) have been identified and some have been incorporated into *Brassica napus* through the synthesis of artificial material. There is further evidence of the high levels of resistance in radicole to clubroot,mildew *(Erysiphe cruciferum)* and downy mildew *(Peronospora parasitica)*.

Improved methods of cross prediction and selection and of reducing the time intervals from the generation of new genetic variation (hybridisation, mutagenesis, etc.) to the production of a potential cultivar, are always being sought. In cereals a major study of methods of cross prediction is nearing completion. This was inititated in 1976 in order to examine the value of triple test crosses in the prediction of performance. It has been shown that valid predictions can be made but at the expense of a great deal of effort. However, F_3 families can be used as a basis for the prediction of the performance of derived inbred lines without having to resort to large numbers of additional pollinations.

07001 *Exploit interspecific and intergeneric crosses as sources of variation for brassica and radicole* (Raphanobrassica) *breeding*

Further crosses were made between a wide range of *Brassica campestris* (2n =20,aa) and *B. oleracea* (2n=18, cc) for the synthesis of *B. napus* (2n=38, aacc) with new variation for use in the swede and forage rape breeding programmes. Interspecies crosses were made at both diploid and tetraploid chromosome levels. Embryos normally abort after such cross pollinations but hybrids may be rescued by *in vitro* culture.The number of viable embryos extracted for culturing was found to be greater from diploid crosses

(16.0 embryos per 100 pollinations) than from tetraploid crosses (1.5 embryos per 100 pollinations).

A new medium, developed in France by Monnier for Cruciferae in general, was used for embryo culture. It induced better growth of very small, immature embryos than previously achieved. During the course of embryo development *in vitro* it became obvious that a slight modification was necessary to reduce the osmotic potential of the medium for continued growth. With these encouraging results, it is planned to use this medium in future.

The low frequency of hybrid embryos available for culture is a drawback to the technique, even if difficulties in culturing small embryos can be overcome. An alternative technique to direct embryo culture has recently been developed by N. Inomata in Japan. This method involved the *in vitro* culture of excised ovaries, several days after cross pollination. Ovaries are left in the starter medium for a period of 40 days after which embryos are removed, at a much more mature stage than normally attained prior to direct culture, and then transferred to an embryo culture medium. Experiments were carried out using this technique but were only partially successful because ovaries, with good, initial development, ceased growing after approximately 14 days.

Over 50 families of artificial *B. napus* forms of diverse parentage, produced earlier using embryo culture, were grown out as transplants from the very limited seed available. The majority of these plants survived the severe frost and selected plants were taken for maintenance by glasshouse pollinations and for integration into the breeding programme. They showed a wide range of morphological variation, particularly in plant habit and leaf characters.

Several autotetraploid forms of *B. oleracea* were grown out and selected plants used in small scale multiplications for conservation and future use in strategic breeding. For the same reasons, seed was also produced of nine hexaploid *B. napocampestris* (aaacc, 2n=58), of varying parentage. The last multiplication of this material was in 1971 and that seed was becoming of low viability.

The *Raphanobrassica* programme is now concerned more with research or strategic aspects rather than direct cultivar production. The main difficulties have been the relatively poor seed fertility and germination, in comparison with rape, together with inherent low dry matter content and poorer lamb fattening ability, as demonstrated by grazing trials. However, high total dry matter yields have been obtained on a number of occasions and high levels of resistances to the major brassica diseases have been demonstrated.

In 1981, 13 advanced *Raphanobrassica* lines were grown in the field, most of which had proven high levels of resistance to virulent races of *Plasmodiophora*, with low or zero disease indices. All lines were raised from seed produced in 1980 which gave satisfactory germination (68-96%) and

good plants were obtained. Relatively poor germination, compared with rape cultivars, has been apparent in some previous years.

Visual comparisons were made with rape cultivars, Lair and Nevin. No yield assessments were attempted. All *Raphanobrassica* lines were scored several times for powdery mildew and high levels of field resistance were confirmed. A few lines showed some premature flowering from an early July sowing, but the best material was non-flowering, vigorous and about as uniform as a typical rape cultivar. Seed production of the most promising material had been planned for 1982, but very few plants survived the prolonged frost conditions. Residual seed from previous multiplications is available for restricted field evaluation. The most vigorous lines have marrow-stem kale in their parentage and have not previously been evaluated for dry matter yield or quality factors.

F_1 hybrids between differently derived *Raphanobrassica* lines, obtained to combine good vigour with high disease resistance, were grown out as transplants at wide spacing. The majority of these plants survived the severe weather conditions in marked contrast to plants in drilled plots at close spacing.

A number of cross pollinations were made in 1981 with a view to the introgression of desirable characters from *Raphanus* into *Brassica* and the development of addition lines.

(I. H. McNaughton, Jill E. Middlefell)

07003 *Collect, assess and maintain genetic material of use to brassica breeders*

Thirty-one cultivars were multiplied in 1980 and a further 14 in 1981. This means that viable seed of a considerable number of cultivars has now been produced from the original collection handed over to the Scottish Plant Breeding Station by DAFS, East Craigs. The next step will be to grow these cultivars in assessment trials and score them for the range of descriptors used by swede breeders. The results will be entered in a data bank for future use in connection with breeding programmes. Further multiplication of the cultivars will then be necessary to give an adequate amount of seed for long term storage.

(Isabel K. Munro)

07006-8 Brassica *Pathology*

Investigation of the relationship between disease development in the clubroot seedling test and in the field continued in 1981 using the forage rape cultivars Lair and Nevin and SCRI 57 (currently in NLT). In a standard glasshouse seedling test in 1980 all Lair and Nevin and 87.5% of SCRI 57 were infected; the disease indices (a measure of disease severity — 100% most severe) were 93.9, 33.3 and 29.2% respectively.

In 1981, after inoculation with the same population of *Plasmodiophora*

brassicae, seedlings were kept in a cold frame for 6 weeks before being transplanted into the field in July. All inoculated plants of Lair became infected and rotted before harvest; when harvested in November, 7.9% of Nevin and 29.6% of SCRI plants were infected. There was no reduction in the fresh weight yield of either Nevin or SCRI 57 in comparison with uninoculated control plots; yields were twice as great from SCRI 57 as from Nevin.

These results are in agreement with earlier work which suggested that, where the same inoculum source is used, a host will survive in the field showing relatively mild disease symptoms and little loss in yield where a disease index between 25 and 50% has been recorded in a seedling test. Hosts with higher disease indices are generally susceptible and those with lower disease indices are resistant in field conditions.

The desirability for breeders of working on an annual basis for seed production has led to the investigation in swedes of the optimum length of cold treatment required for floral intitiation (SPBS Ann. Rep. 1980-81, p. 62). Where material also needs to be screened for resistance to *P. brassicae*, a period of 6 weeks at 20°C in a standard clubroot test prior to the cold treatment could delay the onset of flowering. In order to investigate the possibility of reducing this period seedlings of the cultivars Doon Major, Marian, Ruta Østofte and Wilhelmsburger Sator were inoculated and kept at 20°C for 0, 5, 10 and 15 days prior to 10 weeks cold treatment at 5°C. Seedlings kept at 20°C for 0 and 5 days showed no clubroot symptoms at the end of the cold treatment but seedlings kept for 10 or 15 days at 20°C developed symptoms equivalent to those in a normal clubroot test scored 6 weeks and 10 weeks after inoculation respectively. The greater delay in onset of flowering was *ca.* 15 days in Ruta Østofte plants which were retained for 15 days at 20°C in comparison with control plants which were put straight into cold treatment. If these promising results are confirmed in 1982 it will mean that the time required for seed production following a clubroot screening test can be reduced considerably.

The trial in which the relationship between the level of powdery mildew infection, yield and other characters was examined using eight fodder rape cultivars (SPBS Ann. Rep. 1980-81, p. 69) was repeated in 1981. Inoculated seedlings of Samo were used as the inoculum source and control plots received one spray application of triadimefon (Bayleton). Lair, Emerald and Canard showed least mildew infection in both years. The ranking of the more susceptible cultivars changed during the season and between seasons; the most severely infected cultivars in 1980 were Samo, Bishop and Early Giant, and in 1981 were Winifred and Bishop. Differences in rate of mildew development were studied on leaf discs and seedlings of resistant and susceptible cultivars of swede and fodder rape by Eileen McCabe, a sandwich course student.

It was possible to group swede cultivars for relative susceptibility to a local population of *Erysiphe cruciferarum* on the basis of seedling tests;

Bangholm Magres, Marian, Seefelder and Angela were the most resistant, and Wilhelmsburger Sator, Acme, Doon Major and Magnificent were the most susceptible of the 16 cultivars tested.

(Cynthia J. Williamson)

07009 *Breed F_1 hybrid and inbred swede cultivars*

Pedigree Breeding Programme

A new breeding series was started by the production of F_2 seed from the hybrids produced for the F_1 swede trial. The F_1 plants were grown overwinter and vernalised to produce seed which was sown in selection plots at the same time that the F_1 lines were sown in trial. From the results of the F_1 trial, selections will be made from the most promising families for the production of F_3 seed. This method produces F_3 seed after 2 years, instead of after 4 years as previously, thereby saving 2 years at the beginning of the breeding programme.

The main trial of the pedigree programme sown in 1981 was the F_4 trial. This contained 200 entries, which were grown in two sets of 100 lines in two-replicate alpha-design trials. A third replicate of each was added to give the equivalent of a three replicate randomised complete block design. Over the two sets analysed as alpha-designs, 41 of the F_4 lines had higher dry matter yields than the mean of the controls (the cultivars Ruta Østofte, Marain and Sator Østofte) but only 14 had higher yields than the highest control (Marian), and none of these differences was significant. The trial was grown on a uniform area of ground, and the alpha-design analysis produced only small differences between the adjusted and the simple means, causing only minor differences in the ranking order.

Comparing the results over two replicates with those over three replicates, with a selection intensity of 10%, 17 lines were common to both top sets of 20 lines. The first exclusion in one set, in comparison with the other set, was at rank 15 in both cases. This applied for two replicates whether considered as alpha-designs or simple randomised blocks.

The number of lines in this trial were more than would normally be expected at F_4 and the implication of these results are probably more relevant to F_3 trials.

Reducing the replicates from three to two would allow an increase of 50% in the number of lines in trial with no change in the labour requirement apart from the greater demands on seed production.

Methods of hybrid production

Outcrossing tests were initiated to study the methods and conditions for producing hybrids using self-incompatibility in swedes. S-allele combinations which would mimic the single-cross, double-cross, modified double-cross and three-way cross, were set up in both insect cages and isolation plots. Each combination was planted with a pollen donor of the same flower colour and with a different flower colour (buff and bright yellow). Most of the isolation plots were severly affected by frost in the

week following transplanting and only the normal and modified double-cross combinations can be compared from these plots.

(S. Gowers, Dorothy J. Gemmell)

F_1 hybrid trial

A half-diallel set of F_1 hybrids, produced by hand pollination, was sown in trial in order to identify high-yielding combinations. In previous trials of F_1 swedes the crosses have been made between commercial cultivars which possessed, in most cases, considerable intra-varietal variation. The lines used in this set of crosses had been self-pollinated for at least two generations and were much more uniform. The results from this trial should, therefore, be more reliable than those from previous experiments.

Swedes do not suffer severely from inbreeding depression, and high yielding inbred lines can be obtained. In this diallel, the lines from the cultivars Ruta Øtofte and Marian were lower yielding than their parents, while those from the cultivars Bangholm Magres, Criffel and Scotia were higher yielding, although none of these differences was significant at the 5% level.

The highest yielding hybrids were from crosses of a Criffel line with the lines from Bangholm Magres and Bangholm Dima. These had dry weight yields of 15 and 14% respectively, significantly higher than the highest commercial cultivar, Ruta Øtofte. In comparison to their parents, these lines had 26 and 31% higher dry matter yield than the highest parent. If these levels of heterosis could be obtained from inbreds which were equal in yield to the highest yielding commercial cultivars, the production of hybrid swedes would become a viable proposition.

Two lines from both Ruta Øtofte and Criffel were included in the half-diallel to examine intra-cultivar heterosis. The results of the intra-cultivar hybrids corresponded with the general combining ability of the lines, with the Ruta Øtofte hybrid showing little heterosis (7%), whilst the Criffel hybrid gave 18% more dry matter yield than the highest parental line.

(S. Gowers)

Inbreeding with cultivars

Selfing and selection continued within several cultivars to produce high yielding and uniform lines. Two old cultivars with low dry matter content, Emerald King and Acme, are being selected because of their distinctness from modern cultivars. The yield of lines from these cultivars did not, in general, compare favourably with the modern cultivars used as controls. Only one of twelve Acme cultivars had a higher dry weight yield than the mean of the controls, and in the case of Emerald King all lines were lower yielding than the mean of the controls.

In the previous trial of second generation lines from Marian, it was found that all selections were lower yielding than the parent cultivar. A further generation of selection was carried out in two families, and one line was

obtained which was only 1% lower yielding than Marian, whilst having a better score for mildew resistance. Selection for mildew resistance has also been successful in Bangholm Magres which in itself is the most resistant commercial cultivar available. A multiplication from a third generation line, originally selected for high dry matter content, was grown in the Field Trials Unit trials at five sites, and gave similar yields to the parent cultivar whilst having higher dry matter content and better mildew resistance at all sites.

Six lines from each of five families selected from Ruta Østofte were grown in trial and continue to show promise. Two families were selected for high dry matter content, one of which had dry weight yields equal to Ruta Østofte but with a mean dry matter content of 11.6% in comparison to 10.6%. The other family had a mean dry matter content of 12.3%, but dry weight yields were lower than from Ruta Østofte. Of the three families selected for high dry weight yield, one family had yields equal to that of Ruta Østofte, but the other two families had yields over 12% higher than the parent cultivar. The parental lines of these families were tested at the National Vegetable Research Station for resistance to turnip mosaic virus (TuMV), and 50% of the plants from one of these high yielding lines were found to be resistant. It appears highly likely, therefore, that a high yielding, TuMV resistant line can be selected from this family.

A further set of selections from the Bangholm Wilby line selected for high dry matter content was tested. The results obtained were similar to those obtained for the previous selections. Two lines had dry matter contents of over 14%, with dry matter yields of 100 and 106% relative to the mean of controls. In comparison, the highest dry matter content of the commercial controls was 10.7%. Two similar lines from the previous set of selections were multiplied together to produce seed which has been submitted for National List Trials.

(S. Gowers, Dorothy J. Gemmell)

Swede material from Welsh Plant Breeding Station

With the termination of *Brassica* breeding at WPBS, swede lines at various stages of development were received by SCRI for further evaluation. Only small quantitites of seed were available and this was sown for observation and selection where possible. Twenty three lines had sufficient seed to sow with a hand drill in a small trial.

Most of the material seemed poorly adapted to Scottish conditions and only four lines exceeded the mean of the controls for dry weight yield. One of those yielded 19% more than the mean of the controls and will be screened for clubroot resistance.

Hardness determination by penetrometer

Because there is some concern over tooth loss in sheep when grazing swedes, a reliable method of determining hardness is required, especially when selecting for high dry matter content. A penetrometer working on a

gradual increase in pressure was found difficult to use and unreliable, as layers of different density were encountered during penetration of the needle, but a simple weighted needle dropped vertically down a tube from a constant height produced consistent results. An indication of hardness is given by the depth of penetration taken to absorb the kinetic energy of the weighted needle. The method was examined in the field by non-destructive testing of three plants from each replicate in the F_1 and F_4 trials. A 4 mm needle with an attached weight of 1.1 kg was used, and dropped from a height of 275 mm. The mean penetration readings, taken over three replicates, ranged from 48 to 66 mm in the F_1 trial and from 44 to 69 mm in the F_4 trial. In general there was a very high correlation between penetrometer reading and dry matter content ($r=0.86$). There were exceptions, however, where lines with higher dry matter content also had higher penetrometer readings than sister lines of the same family. These exceptions may provide an effective basis for selection to produce softer swedes with higher dry matter content from within such families.

(S. Gowers)

Advanced Swede Lines

In 1980, 22 F_6 or F_7 lines were in trial at the Murrays farm along with six controls, two of which were the cultivars Angus and Melfort (SPBS Ann. Rep. 1980-81, p. 63). The Field Trials Unit carried out trials in the same year at four sites: the Murrays farm, Tritlington Hall, near Cockle Park, Northumberland, Yonderton Farm near Ayr and Westerton of Pitarrow, Laurencekirk. Included in these four trials were eight of the above 22 lines, three other advanced lines and five controls, one of which was Angus.

In the breeders' trial Angus and Melfort did best overall, followed by Da 600 and Da 502, the latter being of interest as it possesses a much lower dry matter content than the other three mentioned. These four were all somewhat superior to cv. Ruta Østofte in overall dry matter yield. In the Field Trials Unit trials genotype-environment interaction was clearly evident over the four sites, but the mean dry matter yield over the four sites showed Ruta Østofte was the highest, followed by Da 703, Da 502 and Da 700. Da 700 is already in National List Trials, Da703 has consistently shown a high dry matter content, but Da 502 requires further evaluation.

In 1981 the Field Trials Unit ran five trials, four at the same sites as those given above and the fifth one at Mylnefield. Melfort gave the highest result in dry matter yield (mean of five sites), followed by two very dark purple lines, Da 344 and Da 697, then by Ruta Østofte and Da 700, but the differences were not significant between those five and the controls. Da 703 also gave the highest mean dry matter per cent, with Da 700 and Melfort second and third respectively. Several of the dry matter contents were significantly higher than that of Ruta Østofte.

(Isabel K. Munro)

Swede trials

The swede cultivars Angus and Melfort completed 2 years in National List Trials in 1980, but the final report is still awaited. They were also included in Recommended List Trials run by the Scottish Colleges of Agriculture. So far, their performance has been excellent.

In 1981 a considerable amount of seed was distributed to farmers under the aegis of College advisory staff. In particular, an appreciable amount of work has been done by the North of Scotland College of Agriculture and is gratefully acknowledged. A great deal of information has been collected from farmers and advisers on the performance of the two cultivars under farm conditions.

Angus and Melfort were found by the West of Scotland College of Agriculture to have a marked resistance to, or tolerance of, attacks by turnip-root fly (SPBS Ann. Rep. 1980-81, p. 25 and 64). This was confirmed in 1981. Turnip-root fly is of special interest to farmers both in the west of Scotland and in the east, north of the river Forth. The insect lays its eggs around the base of the swede in early July and, if the larvae penetrate the bulbs, extensive damage may be caused. Such damage renders bulbs unsuitable for culinary markets and in some years heavy losses may result. Experiments have been undertaken in collaboration with both the West and North Colleges during the past 2 years to establish the mechanism of this resistance.

(Isabel K. Munro)

07010 *Breed rape cultivars from natural and artificial genotypes of* Brassica napus *and related species*

The three pronged approach to forage rape improvement was continued, with contributions to the programme from inter-cultivar crosses, interspecific hybrids between *Brassica oleracea* and *Brassica campestris* (SPBS Ann. Rep. 1979-80, p. 44) and cultivars treated with the mutagenic chemical ethyl methane sulphonate (EMS). Glasshouse tests demonstrated that the best chance of increasing resistance to the major disease, clubroot *(Plasmodiophora brassicae)*, comes from the interspecific hybrids, while field observations suggest that such hybrids may also have better resistance to the other major disease, powdery mildew *(Erysiphe cruciferarum)*. Accordingly the proportion of the programme devoted to interspecific hybrids has been increased, a fact which was reflected in the 1981 crossing programme where 14 of the 21 parents used were either *B. napus*, synthesised from *B. oleracea* and *B. campestris*, or the progeny of synthetic *B. napus* crossed to one of a number of forage rape cultivars.

In contrast, all the material in the 1981 F_2 generation selection plots came from intercultivar crosses. Also included with this material were 112 plots of swede x rape crosses, previously selected for two generations for rape characteristics. Single plants were selected for bag selfing from both blocks

of material following visual assessment for height, branching, non-flowering, mildew resistance and winter hardiness.

A two replicate, randomised complete block, F_3 trial, with six control cultivars, Lair, Canard, Emerald, Winfred, Samo and Nevin, and six breeding lines, was sown at the Murrays farm. The breeding lines were all synthetic *B. napus* from the cross *B. oleracea* (marrow stem kale) x *B. campestris* ssp. *nipposinica* made at the tetraploid level, and previously selected for high tillering and non-flowering. Largely on the basis of both fresh weight and dry matter yield, but also taking mildew resistance into account, three of the six breeding lines were retained for seed production and F_4 trials, having significantly out-yielded the mean of the controls. The mean fresh weight yield of the controls was equivalent to 42.08 t/ha.

A four replicate, randomised complete block, F_4 trial, with the same six control cultivars as the F_3 trial and ten breeding lines, was also sown at the Murrays farm. The breeding lines were all hybrids between a synthetic *B. napus* line (from thousand head kale, curly kale and *B. campestris ssp. nipposinica),* and the cultivars Nevin and Samo. Assessments similar to those on the F_3 material were carried out on the basis of fresh weight and dry matter yield, mildew resistance and chemical analyses; five lines were retained for seed production and F_5 trials. All five lines significantly outyielded the mean of the controls which had an equivalent fresh weight yield of 43.91 t/ha.

Selections from both trials will be assessed for their resistance to clubroot.

As a means of obtaining further data on the forage rape SCRI 57 (formerly SPBS 5/7/10/1) which was in the first year of National List Trials, it was included in the Field Trials Unit trials at four sites — East Lothian, Ayr, Dundee and Newcastle. In a three replicate, randomised complete block trial, SCRI 57 was compared with its sister line, SCRI 58, and the cultivars Barsica and Tantal, using the cultivars Canard, Emerald, Lair and Winfred as controls. Due to poor growth at Newcastle, and inadequate weed control and drought at Dundee, no useful information was obtained at these sites. In the other two trials, SCRI 57 confirmed its high fresh weight yield and mildew resistance, though the dry matter yields were disappointing, possibly due to the very dry year.

The effect of seed size on yield was investigated in a four replicate, randomised complete block trial sown at one site, using the rape SCRI 57. Seed was graded into three categories: 1.50 to 1.75 mm, 2.00 to 2.25 mm and 2.75 to 4.50 mm. The second of these categories would be considered normal for forage rape; seed in the third category only being available as the result of a very successful multiplication in New Zealand. The effect of dressing the seed with aluminium ammonium sulphate (Seedguard), which is claimed to repel the attacks of birds and small mammals, was also investigated in this trial. The largest seed size gave a significant increase in both fresh weight and dry matter yield over the smallest seed, but there were no significant differences in other characters such as height, mildew

resistance and dry matter percentage. There was no significant effect of using Seedguard on yield or plant population, though treated seed emerged 1 or 2 days earlier.

Inter-plant spacing was investigated in a four replicate, randomised complete block trial using SCRI 57 and Lair, with four different spacings along the row. These were 5.1, 6.4, 10.2 and 16.5 cm, set by altering the gear ratios on a Webb precision drill. Inter-row spacing (0.5 m) and seed size (2.00 to 2.55 mm) were kept constant. There was no significant effect on yields, dry matter percentage or height.

A first investigation into the procedures of direct drilling forage rape into killed grass was carried out using a Gibbs drill and comparisons were made between potential new and existing cultivars.

(W. H. Macfarlane Smith)

07011 *Breed kale and fodder cabbage cultivars*

Kale Breeding

The main objective is to improve the nutritional value of fodder kale by lowering the SMCO (the haemolytic factor) and SCN^- (a goitrogen) contents, whilst maintaining high digestible organic matter (DOMD) and crude protein contents. As kale can be utilised from the beginning of October to the end of March, these contents were determined for cv. Maris Kestrek kale on fourteen occasions during this period in 1980/81.

Consideration is also being given to improving clubroot resistance. One hundred and twenty marrow-stem kale plants, which exhibited some resistance in seedling tests in 1980, were planted in an isolation site for seed production in 1981. Seed was harvested from 105 plants in the autumn of 1981.

An increasing proportion of the kale acreage is direct drilled into killed grass in June after early grass grazing or a first silage cut. Therefore, in 1979 and 1980, potential new cultivars were compared with existing cultivars in a direct drilled trial using a Gibbs drill, as well as in conventionally drilled trials.

Work continued on the small kale polycross improvement programme started in 1971. The fourth generation was assessed in 1981. Four third generation families were mass-multiplied in 1981 in order to provide seed for more extensive trials in 1982. A distinct winter hardy, late flowering, high dry matter content, family from the second generation (PX 21/150/91) was selected for increased uniformity. The new stock (SCRI KB21) has been entered into National List Winter Kale Trials in 1982.

Research into methods of kale breeding and cultivar production continued both experimentally and theoretically through computer simulations.

Fodder cabbage

A small fodder cabbage programme was started in 1978. 1981 was the seed production year for the first selected generation. Breeding objectives are rapid establishment, high dry matter yields and contents, low SMCO and SCN^- contents, and improved clubroot resistance. The aim is an open-pollinated cultivar for early, and hence cheap, seed production.

(J. E. Bradshaw)

07015 *Test and multiply brassica, radish and radicole cultivars*

A Stocks Unit has been set up to deal with multiplication of seed and purity testing for all *Brassica* workers at Pentlandfield. Advanced breeding material only will be assessed, rogued and multiplied, to produce as uniform and pure a stock as possible for trials by the Field Trials Unit. Further multiplications will be required to prepare these advanced lines from the breeders for submission to the National List Trials. A start was made to this work in 1981, when the Stocks Unit took over multiplication, using tunnels or houses covered with polythene, and tunnels or insect cages covered with Tygan. Other materials are being examined to ascertain which will give the best, and most natural conditions for seed production and, at the same time, be reasonably durable.

In 1981, 74 insect cages of different sizes and 54 polythene (or other material) tunnels and houses were used for multiplication. Where more seed was required for submission to NLT, the larger numbers of plants necessitated the use of four plots in East Lothian. Amounts of seed produced in 1981 were on the whole good and more than sufficient for further trialling.

(Isabel K. Munro)

08001 *Collect, assess and maintain oat and barley genotypes of use to breeders. Use computer-based data systems*

Additions over the past year have brought the barley collection to 3140 entries, while the oat collection remained at 1167 entries and work on it ceased. Both collections were sown in the spring. The barley collection was scored for powdery mildew, awn emergence date and straw length. Replacement stocks were harvested where necessary for both collections.

The development of computer programmes designed to facilitate the maintenance of the collections and the handling of data continued:

1. The MUSEUM package (SPBS Ann. Rep. 1980-81, p. 84) which maintains data bases for the collections and from which catalogue and stock information may be drawn proved to be of value in the production of catalogues, field plans and packet and harvest labels. It was extended to store pedigrees and to print morphological diagnostic symbols on field plans and labels. This latter facility is intended to improve error trapping

by enabling the observer, while scoring, harvesting or threshing, to check that the material conforms with the expected type. A hand held terminal (SPBS Ann. Rep. 1980-81, p. 114) used in conjunction with a bar-code reader greatly improved the storage of harvested seed weights in the data bases.

2. Observations on the collections have accumulated over recent years into a large unwieldy body of data. The DATAPACK program (SPBS Ann. Rep. 1980-81, p.84) has simplified the taks of converting these data into a useable form. Scores may be averaged over seasons even when the data are incomplete and the distribution of the resulting means may be examined for normality. The program allows the user to transform these data prior to reduction to a 1-9 scale used by the EXIR based data bank. Many data were filed this season and updates on the data bank were completed for awn emergence, powdery mildew susceptibility, straw length, first leaf length, soluble beta-glucan content, milling energy and protein sedimentation ratio.

3. The updating procedures for EXIR are very laborious and error-prone. The EXIR UTILITIES program was developed to cope with these difficulties and it provides the following functions:

   (a) Compilation of Correction statements. New data may be transferred from DATAPACK to replace existing values or may be compared with existing data from the data bank to eliminate unnecessary statements. The statements are automatically placed in a complete EXIR job command file.

   (b) Conversion of EXIR output to a form readable by the Correction statement part of the program.

   (c) Compilation of new item statements. The operator provides the descriptor data available and statements are automatically prepared and placed in a complete EXIR job command file.

   (d) Maintenance of the current control vocabulary. This catalogue is used to check the validity of descriptor and state names keyed in by the operator so that invalid statements, which would cause failure of EXIR, are avoided.

   (e) Automatic transfer of files between EMAS and Cambridge where the data bank is located.

Additional work on program development was necessitated by the adoption at ERCC of Fortran 77, the most recent Fortran standard. Much of the software described requires character handling capability which is available in only rudimentary form in older Fortran standards. Consequently, it was thought to be desirable to upgrade the DATAPACK and UTILITIES programs.

(R. J. Giles, J. C. Penman, D. M. Farrer, Mairi L. Williamson)

08003 *Study inheritance of cereal performance characters. Design procedures to maximise and exploit variation.*

The investigations of cross prediction in spring barley were continued in collaboration with Professor J. L. Jinks[1] (SPBS Ann. Rep. 1980-81, p. 73-74). C. R. Tapsell, a CASE student, continued to analyse the data. Analysis of characters scored on a single plant basis in the triple test cross and model-fitting experiment was completed. The results are being used to predict the proportions of inbred lines that lie outside the parental range of the various crosses. Results so far suggest that the predicted performance of a cross, based on a single plant yield, agrees well with the observed performance of a cross, based on small plot yields of the derived inbred lines. Estimates of the statistics necessary for cross-prediction, namely the mean and additive genetic variation of a cross were also obtained from F_3 families of the crosses under study. The predictions made using these estimates were in good agreement with those obtained from the triple test cross and model-fitting experiment.

Additional random selections from the crosses Golden Promise x Ark Royal and BH4/143/2 x Ark Royal were raised in yield trials in 1981. With a comparatively late sowing, the trials were extensively damaged by rooks feeding on the sown seed. Results from these trials will therefore need to be interpreted cautiously. However, single plants were recovered from each plot and are being scored in the laboratory for the components of yield, height and neck length.

V. Rao, a student from Birmingham University, analysed some of the data collected on the genotype x environment study.

Although the results of the cross predictions, based on statistics estimated from the triple test cross and model-fitting analysis showed promise, the considerable amount of work involved means that only a very few crosses can be studied in this way each year. However, as already noted, predictions based on statistics estimated from F_3 families were similar. The advantage of F_3 families is that only generations normally produced in a pedigree plant breeding programme are required. Also, considerably fewer generations and lines need to be assessed, enabling more crosses to be examined in a year. In 1981, a pilot experiment was carried out on six crosses from the breeding programme; F_3 families from each cross were raised in randomised complete block designs at two sites. Single plants were recovered from each family in each replicate at each site for subsequent analysis of height and the components of yield.

(W. T. B. Thomas, J. S. Swanston, T. Nelson)

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[1] University of Birmingham

08004 *Evaluate techniques for choosing parents and selecting offspring. Design data handling system for breeders.*

The experiment investigating the use of single seed descent coupled with selection (SPBS Ann. Rep. 1980-81, p. 74) was sown in the field in 1981. Heights and the components of yield were recorded on single plants to allow comparison of the unselected and selected populations. Preliminary results suggested that selection had altered the population means in the desired direction but for the particular crosses studied the differences were not statistically significant.

An examination of the F_2 populations of crosses between barley genotypes with several different dwarfing genes marker stocks (SPBS Ann. Rep. 1980-81, p 74) showed that a non-random loss of genotypes had occurred during the early drought of 1980. No reliable estimates could therefore be obtained from this study. However, the results from another study provided further evidence of linkage between the erectoides dwarfing gene found in the cultivars Midas and Golden Promise and a gene on chromosome 7 determining short rachilla hair.

The development of techniques which are potentially useful in both spring and winter barley breeding continued. These included further development of single seed descent using nutrient film techniques, the *Hordeum bulbosum* method of doubled monoploid production, and investigations of pollen irradiation and anther culture derivatives.

(A. M. Hayter, R. P. Ellis, W. T. B. Thomas, W. Powell, J. S. Swanston, Valerie Goodall, T. Nelson, W. Wood)

08007 *Study mechanisms of partial resistance of oats and barley to* Erysiphe *and their use in resistance breeding*

Evaluation continued of selections from the barley germplasm collection exhibiting potentially useful levels of partial, non-hypersensitive resistance to powdery mildew *(Erysiphe graminis* f.sp. *hordei)*. Some of these were grown as $1.5m^2$ plots in a replicated field trial and their performance compared with some currently popular commercial cultivars. All plots were exposed to virulent inoculum introduced on infected plants from the glasshouse at the beginning of the season and the progress of the epidemic was monitored within each plot at intervals of 10 days thereafter. Though susceptible as seedlings, the rate of epidemic development was markedly reduced at middle and late growth stages in genotypes exhibiting adult plant resistance of the non-hypersensitive type. Several were significantly more resistant in the field than cv. Proctor and equal to, or more resistant than, some cultivars possessing major gene types of resistance.

In a small-scale genetical investigation, eight partial mildew resisters were crossed and backcrossed to a common, mildew-susceptible parent (cv. Golden Promise) and the six basic generations (P_1, P_2, F_1, F_2, B_1 and B_2) derived for each cross. The generations were sown in four randomised

blocks, each replicate consisting of a row of 20 spaced plants bordered on either side by a row of Golden Promise to act as a mildew spreader. At anthesis, the percentage mildew on the upper three leaves was assessed on 10 randomly selected plants within each row. All plants were harvested and the stem height and yield components determined. Model-fitting analysis of the mean mildew scores showed evidence of significant additive and dominance components in most crosses with significant epistasis in some.

In laboratory studies, the resistance of leaves from different positions on the main stem of the plant, but of equivalent physiological age, was examined. This was done by staggering sowings in a spore-proof glasshouse. The second youngest fully expanded leaf was cut from plants that had been sown at different times and a 35 mm long segment from this was inoculated in settling tower. A progressive reduction in the number of pustules developing per unit leaf area (infection frequency) was evident on successively produced leaves, even on susceptible control cultivars and varieties. However, the effect was much more pronounced in those genotypes selected for adult plant resistance in the field. Further work is in progress to determine whether other resistance components such as latent period and sporulation intensity contribute to this resistance.

Microscopic examination of segments of Leaf 5, cleared and stained 72 h after inoculation, revealed that several different resistance mechanisms were operating at the cellular level among the different host genotypes. In one genotype, the resistance appeared to be due predominantly to hypersensitive death in those cells first challenged by the germinating spore. Because this hypersensitivity was restricted to individual cells, it was not evident as a macroscopic symptom. In another genotype failure to penetrate or to form haustoria in cells, which otherwise appeared unaffected, was the main component of the resistance. Where the majority of germinated spores had initiated successful colonies, as in susceptible genotypes and cultivars and some of the partial resisters, there were differences in the average rate of colony growth. Work is in progress to confirm and extend these findings.

A rapid method of counting spores of foliar pathogens, using infra-red reflectance analysis, has been developed in collaboration with the Chemistry Division and is described in more detail on p. 147. The method will enable an assessment of the contribution of reduced sporulation intensity to partial resistance in host genotypes.

(M. J. C. Asher, Clare E. Thomas)

08009 *Study biochemical components of barley and oat grains related to malting, feeding and processing quality*

B-amylase measurement by a nephelometric technique.

When β-amylase (Henley Co., New York) was added to a solution of Lintner starch, rapid alteration of the light-scattering properties of the solution occurred, as the starch was broken down. The rate of breakdown was related

to the concentration of the enzyme. It was possible to determine the β-amylase content of different barley genotypes using a simple nephelometric technique, which is potentially useful when breeding barleys with high diastic power.

(J. S. Swanston)

08013 *Breed malting and feed barley cultivars*

Three sping barley cultivars were included in second year National List Trials (NLT2) in 1981. The cultivars Tweed (SPBS 648/18/68) and Eden (SPBS 648/18/85) proved to be indistinguishable and Eden was withdrawn because of a slightly poorer yield and an inferior brown rust resistance. Tweed was granted Plant Breeders' Rights. Cultivar Tay (SPBS 213/11/4) also completed the Value for Cultivation and Use trials but requires a further year of Distinctness, Uniformity and Stability testing before it can be granted Plant Breeders' Rights. Both Tay and Tweed were selected for Scottish Colleges Recommended List Trials but neither was accepted for further testing in England and Wales. This was a particular disappointment in the case of Tweed because there was good evidence, both in official and informally conducted trials in 1980 and 1981 that the cultivar yielded well in more northerly sites in England. Three cultivars, Almond (SPBS 176/193/34), Don (SPBS 297/1/2/3) and Leith (SPBS 650/15/18) were included in NLT1 in 1981 and all performed sufficiently well to progress to NLT2 in 1982.

The Joint Main Trial (JMT) series (SPBS Ann. Rep. 1980-81, p. 78) continued in 1981 with some slight changes. Whereas the five trials centred on the Plant Breeding Institute and the two centred on the Welsh plant Breeding Station were grown as 7 x 7 lattice squares, the five centred on Pentlandfield were grown as 50 entry generalised lattice designs, the extra entry being cv. Golden Promise treated with a mildew fungicide. This alteration suited trial handling at Pentlandfield, as well as providing a comparison with Golden Promise which should be more meaningful in Scotland. A further change was the introduction of trials with four replications at SCRI, PBI and WPBS. At each site, two replicates were treated with triadimenol with fuberidizole (Baytan) and the other two were untreated. This provided a comparison of potential NLT submissions with and without fungicide. However, this comparison did not prove worthwhile for a variety of circumstances, including the limited effectiveness of the fungicidal seed treatment. From this trial series five NLT1 submissions were made for 1982. SCRI 300/6/14/5, SCRI 300/6/9/11 (both Trumpf x HB 855/467/7) and SCRI 212/15/11 (Trumpf x Aramir) are high yielding selections with good all-round disease resistance, the first being early maturing. SCRI 184/14/7 (Georgie x Trumpf) and SCRI 295/14/5 (Trumpf x Hassan) combine high yielding ability with good all-round disease resistance and potential malting quality. As in 1980, all entries in the trial series were also tested in various disease nurseries at the three centres. Both SCRI and

PBI selected two trials as sources of material for micro-malting analysis. Thus, each NLT submission was accompanied by a great deal of reliable information. This is felt to be the major benefit of the JMT series, but evidence was also provided of adaptation of selections to either the Scottish or to the English and Welsh environments.

Entries in Breeders' Preliminary Trials in 1981 included selections from the following crosses: Athos x Hood, BH4 x Hoppel, (BH4 x Armelle) x Aramir, BH4 x (Goldmarker x Ambre), Maris Mink x (Armelle x Golden Promise), (Universe x AF11) x Sabarlis, (BH212 x Hassan) x Minak, Goldmarker x (Ark Royal x Golden Promise), BH644 x (Magnum x Aramir), BH648 x (Minak x Aramir) and BH648 x (Minak x Hassan). All of the selections from the F_3 nurseries were screened with the Comparamill to identify lines with low milling energy and thus potential malting quality.

The exchange of F_4 selections between the Agricultural Research Service barley breeding stations (SPBS Ann. Rep. 1980-81, p.79) continued in 1981. SCRI received approximately 1,800 selections from PBI and WPBS from which 50 selections were retained for further study.

The speed of yield analysis at harvest was improved by the use of an electronic balance interfaced with an Apple II micro-computer.

Using a program developed by the Statistics and Computing Unit, plot yields were logged and recorded on floppy disks. The data were stored in an order suitable for analysis by the CVT package and could be transferred from the floppy disk via the Apple II to the main-frame computer on which the CVT package was mounted. The use of the CVT package has been proven over the past few years; the data-base package being developed by the Commercial Potato Breeding Department is also thought to be potentially useful for handling breeding material and it will be evaluated in 1982. Further efficiency in the general administration of field and laboratory work was achieved through increased use of both micro-computers and main-frame computers.

In 1981, conditions were favourable for the development of a heavy epidemic of powdery mildew (*Erysiphe graminis* f.sp. *hordei*), thus allowing selection against susceptibility to this disease. Syringe innoculations of yellow rust (*Puccinia striiformis*), together with infected neighbouring winter barley trials, encouraged a heavy epidemic of the disease and selection against susceptibility. Straw infected with *Rhynchosporium secalis* was spread on some of the early generation nurseries but the disease was patchy and no worthwhile selection against susceptibility was possible.

(A. M. Hayter, R. P. Ellis, W. T. B. Thomas, W. Powell and J. S. Swanston)

08014 *Breed spring oat cultivars*

Cultivar Fyne was removed from the Provisional General category of the NIAB Recommended List, following a relatively poor performance in official trials in 1981. Fyne was the last cultivar to be produced from the

Scottish spring oat breeding programme, which has now been stopped. The Welsh Plant Breeding Station have assumed responsibility for oats for the United Kingdom, but a collaborative programme will be established with SCRI. Material from the intermediate generations of the Scottish programme also yield poorly in 1981, probably as a result of the introduction of major dwarfing genes and relatively little material remains to be evaluated in 1982. Under the new collaborative arrangements for trialling and testing, material generated at WPBS specifically for Scottish requirements is only just becoming available at F_2. It will be several years before the effectiveness of the new procedure can be judged.

(A. M. Hayter, W. T. B. Thomas, J. S. Swanston)

08015 *Produce pure seed stocks of new cultivars. Investigate diagnostic features of oats and barley.*

Approximately 240 stocks derived from more than 50 selections were retained from Breeders' Preliminary Multiplication in 1981 and from material grown in New Zealand during the 1981/82 winter.

Leaf stripe, a seed transmitted disease in spring barley caused by *Helminthosporium gramineum* was detected in most stocks in 1981 at varying but low levels. The affected stocks were rigorously rogued and all stocks were treated before and after anthesis with Mancozeb (Dithane) and Carbendazim (Bavistin) fungicides. The presence of the disease is a continuing problem because it causes loss of yield, it makes observations of DUS ear rows difficult and, most importantly can result in a candidate being rejected from official trials leading to a grant of Plant Breeders' Rights. The spraying of these fungicides is to continue as a routine part of cereal stocks husbandry.

The development of computer programs written in Fortran 77 and Pascal to manipulate diagnostic characters for stocks administration continued. These programs are designed to replace the tasks of producing field plans, sowing-packet labels and harvest labels. They are being integrated in a data base package which also includes a facility to update stocks information continuously from one season to the next. In addition, a procedure is being written to process the recorded field observations to give a 'stocks report' for each potential cultivar at each generation. This will be an aid to the breeders when considering NLT submissions. The Apple II micro-computer is used for data capture and the data base is maintained on the ERCC main-frame computer.

(R. J. Giles, J. C. Penman, D. M. Farrer, Mairi L. Williamson)

POTATO DIVISION

J. H. W. HOLDEN

During the year there was an intensive evaluation of the diploid and tetraploid material of the Strategic Breeding Department which involved much routine screening for disease resistances by the Potato Pathology Department in addition to the normal commitment to screening material from the commercial breeding programme. Readings on the progeny of the 1980 exposure trial to potato virus Y (PVY) and potato leafroll virus (PLRV) at PBI Cambridge revealed low frequencies of infection, due presumably to low aphid populations in that year. In the 1980 potato mop top virus exposure trial infection was extensive through the trial site and infection frequencies were high in the susceptible controls. These two experiences highlight again the need to develop tests which can be done under controlled conditions and which give consistent results from year to year and good correlation with field performance.

The desirability of standardising screening tests was given emphasis during the year by the scores for disease resistances given in the official reports on the National List Trials of the new cultivars Provost, Baillie and Sheriff. In several cases our assessments differ significantly from the official descriptions which is of concern when the cultivars have been selected for, and would be marketed with reference to, high levels of disease resistance. Our experiences this year have been focussed on this point but they identify a problem which has a wider relevance as disease resistance breeding becomes more common and more successful.

Evaluation of the strategic breeding material derived from tetraploid Andigena and diploid Phureja-Stenotomum, confirmed earlier indications of promise. An extensive screening programme for reaction to the major potato pathogens revealed levels of resistances equal to, or greater than, the high-resistance controls for common scab, gangrene, foliage blight, PVY (including comprehensive resistance to all strains of the virus). Great variation was found in tuber quality characters such as dry matter content, crisp and flesh colour. Trials have demonstrated the potential for high yields of ware sized tubers in selected clones of Neo-Tuberosum, in Neo-Tuberosum x Tuberosum hybrids, and in (Phureja-Stenotomum x Tuberosum) hybrids at both the diploid and tetraploid levels.

Since the announcement that the Commonwealth Potato Collection is free from infection by potato spindle-tuber viroid (SPBS Ann. Rep.

1980-81, p. 103), the Collection has not been reactivated but distribution of seed has continued.

In September Plant Breeders' Rights were granted in respect of the cultivars Provost, Baillie and Sheriff, and all three have been entered on the National List.

In the longstanding programme of breeding for resistance to the white potato cyst nematode (PCN) *Globodera pallida*, based on the resistance of the wild diploid species *S. vernei*, progress has been relatively slow because of the difficulty of combining high levels of resistance with acceptable yield and quality characters. However, promising material is now emerging from the bottleneck and six clones resistant to *G. pallida* were included in regional trials in 1981. Additionally, these six clones were included in field trials to assess their tolerance to root invasion by PCN larvae. The trials revealed large differences between the clones in yield depression on infested plots compared to yields on plots treated with a nematicide. The trials not only permitted selection against intolerant clones but clearly showed the need for regular screening for this character among all PCN resistant material. There can be little doubt that henceforth breeders must select for the effect of the pathogen on the host as well as for the effect of the host on soil populations of the pathogen.

Rapid progress was made in writing a computer package, which will control the recording, updating, analysis, storage and organised display of all data on clones under selection in the commercial breeding programme. Although it is still in the early stages of development, this project is expected to simplify and improve data processing.

Arrangements for the organisation of trials overseas were completed during the year. The National Seed Development Organisation, in conjunction with Matutano S.A., agreed to be responsible for the trialling of advanced clones from the three United Kingdom potato breeding programmes at four centres in Spain. Trials are limited to a total of 20 clones and to material at the stage of UK National List Trials or one year earlier. Additionally, SCRI, together with PBI, have arranged with Matutano S.A. for the trialling of up to 100 clones at an earlier stage of selection than those in the NSDO trials. Accordingly, it is hoped to increase the probability of identifying clones adapted to early production in Southern Spain and to maincrop production in the North.

Arrangements were also made for the trialling of similar material at the Gilat Experimental Station in Israel.

09001 *Breed maincrop potato cultivars for quality, disease resistance and yield for fresh use and processing*

The early maincrop cv. Sheriff, (clone 7495(6)) and the second-early cv. Baillie, (8990(7)) successfully completed National List Trials (NLT) and were entered on to the National List. The names Fiona and Kirsty for

maincrop clones 8911 abc 15 and 9006(6) respectively have now received official approval. They have completed their second year NLT and a decision on their future is anticipated from the statutory authorities in 1982. There were no submissions in 1980 and therefore no SCRI clones in first year NLT in 1981, but two maincrops, 10333 ab 18 and 10442(8) were submitted in Autumn 1981 for Plant Variety Rights (PVR) and NLT in 1982.

Breeding for potato cyst nematode (PCN) resistance

The screening of clones bred for resistance to PCN continued to contribute to an understanding of the host/pathogen relationship and provided guidance on breeding strategy. Bulk seedling tests on samples of progenies tracing their resistance to *G. pallida* from Andigena CPC 2802 clearly confirmed that this source of resistance is truly polygenic, and not due to a major gene (H_1) as was originally believed (Howard H. W. *et al* (1970), Euphytica *19*, 210-219). The data from these seedling tests also demonstrated that differences in general combining ability account for practically all the variation when highly resistant, sub-commercial clones are hybridised with susceptible cultivars, as is the practice in the early stages of a breeding programme. However, as the general levels of resistance in the breeding programme increase and the more resistant sub-commercial selections are intercrossed specific combining ability becomes a significant factor. This underlines the importance of progeny testing and the usefulness of the bulk seedling test as developed for this purpose at SCRI. When applied as a routine test on samples of all progenies emanating from the PCN resistance breeding programme, it permits the rapid identification of the more resistant progenies, and provides useful information on the inheritance of resistance and hence the breeding value of parent clones.

Two field trials for the assessment of tolerance of the six most advanced PCN resistant clones in the programme were undertaken in 1981 with the co-operation of Dr. P. Mathias[1], and Dr. D. Trudgill[2]. These trials at a site infested with *G. pallida* near Cambridge and a site infested with *G. rostochiensis* near Dundee, demonstrated considerable differences between the clones in levels of tolerance. Tolerance is expressed as the difference in yield of clones when grown in infested and nematode free land. The most intolerant clone exhibited a 90% yield reduction in the untreated plots at the site infested with *G. pallida* compared with only 20% in another more

[1] Agricultural Development and Advisory Service, Cambridge.
[2] Zoology Section.

tolerant clone. On average, all clones appeared more tolerant of *G. rostochiensis* than *G. pallida* but more data from other sites and in other seasons are necessary before this can be assumed to be the general case. The most important point to emerge was the lack of correlation between resistance and tolerance, thus underlining the necessity for screening for tolerance *per se* as well as for resistance.

Virus resistance breeding

The interpretation of data from seedling progeny tests in 1980 was completed and several clones duplex for their PVY resistance genes were identified and selected for further hybridisation, in order to produce triplex or quadruplex parents for future commercial breeding. Several clones from this specialised programme and of proven virus resistance are currently undergoing selection as potential cultivars. Their performance in 1981 in terms of yield, quality and resistance to fungal pathogens was comparable with contemporary clones originating from other parts of the commercial breeding programme. It is anticipated that at least three will be selected for regional trials in 1982 as potential cultivars; others will be considered as parents.

(G. R. Mackay, P. D. S. Caligari, M. F. B. Dale, J. Brown, Jean Spence, G. E. L. Swan)

09002 *Breed early potato cultivars for early yield and quality, in relation to fresh use, crisping and canning*

The first early cv. Provost, (clone 7169(10)) successfully completed NLT and was entered on to the National List in 1981.

In Autumn 1981, clone 9869a9 was submitted for NLT. In many respects 9869a9 is similar to Provost, also of excellent table quality but more resistant to gangrene and spraing (TRV).

(G. R. Mackay, P. D. S. Caligari, M. F. B. Dale, J. Brown, G. E. L. Swan, Jean Spence)

09003 *Maintain and multiply healthy breeding and experimental stocks, develop and apply improved health control procedures*

The incidence of virus disease in most stocks was extremely low and continued the decline of previous years. One or two stocks showed an increase in the incidence of blackleg, but this did not become a problem and all advanced clones submitted for inspection received an approved stock certificate from DAFS.

The use of flat pallets in the field and store greatly increased the efficiency of handling. Their use, and a mild, dry spell of weather resulted in the harvest at Blythbank being completed in 3 weeks, a week less than usual.

(G. R. Mackay, C. J. W. Torrance)

09005 *Evaluate advanced potato selections in field trials in Scotland, England and Wales*

1981 was the second year of joint trials of advanced clones from SCRI, PBI and DANI. A favourable spring and mild autumn permitted expeditious plantings and harvest at three sites but a wet spell in spring delayed planting at Terrington EHF and at Arthur Rickwood EHF. This, followed by a drought after planting, particularly at the former site, led to somewhat low yields and small tuber sizes at these sites. There were 24 entries in the trials; 16 from SCRI, two from PBI, two from DANI and four control cultivars. cv. Fiona, currently completing National List Trials was included amongst the SCRI clones and performed well. Two other clones, 10333ab18 and 10442(8) confirmed their promise as adduced from previous years' trials and the decision was taken to submit them for Plant Variety Rights and NLT. Four other SCRI clones performed sufficiently well to be resubmitted for trial in 1982, with a view to submission for statutory trials in 1982. The remainder have been withdrawn from further trialling but one or two which possess special attributes such as high levels of scab and PCN resistance may merit use as parents.

Ten clones and seven cultivars, including Baillie and Provost,were grown in first early trials at Trefloyne and Penrice in Wales, at Cairnside, Wigtonshire, and at the Murrays farm. Provost and Baillie performed well and the latter, though not a first early, produced a moderate yield at the early lifts and outyielded cv. Estima, the highest yielding control, at the second lift at Trefloyne.

Overseas trials

Baillie and Fiona were trialled at Valencia on mainland Spain and at La Puebla in Majorca. Both performed well and, despite an extremely hot dry spell and an outbreak of early blight (*Alternaria*), which caused premature senescence at the latter site, Baillie compared favourably with the control cultivars. Arrangements to trial larger numbers of less advanced clones in Spain were made with Matutano S.A. and seed tubers of 84 clones were despatched in October for trial at Valencia. The same clones will also enter a maincrop trial at a northern site in 1982. In addition to these breeders' trials, eight advanced (pre-NLT and NLT) clones have also been despatched for inclusion in NSDO trials in Majorca, at Valencia, Malaga and Burgos.

Arrangments were also made to trial SCRI clones in Israel in 1982 and seed of 50 clones was despatched in October.

Several advanced clones, including the cultivars Baillie, Sheriff, Provost, Fiona and Kirsty were trialled and evaluated by the Potato Processors' Association, J. Mason[1], and A. & H. Worth and Co., Holbeach.

(G. R. Mackay, P. D. S. Caligari)

[1] Agricultural Development and Advisory Service, March.

09007 *Research into design and predictive efficiency of potato field trials and into G x E interactions*

For the third consecutive year the regional maincrop trials were planted in a generalised lattice design. In such a design each complete replication is subdivided into a number of incomplete blocks. It is resolvable (i.e. the data may be analysed as if from a randomised complete blocks design) so a comparison may be made of the designs by analysing the same data by two methods. In theory, the generalised lattice design should give smaller errors because variation between the blocks within replicates can be accounted for. In the randomised complete block analysis such variation is included in the blocks x entries interaction mean square which may therefore be inflated by variation arising from soil heterogeneity within replicates.

Experience has shown this to be generally the case although the increases in precision have been relatively modest. For example, the adjustments to the means were about 2%. Although the generalised lattice design can never give a less precise analysis than the randomised complete blocks design there appears to be little to gain from the more sophisticated design unless the trial is large when the advantages become more marked.

(R. J. Killick)

09009 *Establish and manage computerised data bank on clones under selection in the potato breeding programme*

A computer package designed to handle all data collected on clones within the breeding programmes was written in FORTRAN E. This package, the Computer Housed Information Package, permits the breeder to specify the number of years over which data will be collected and the type and amount of data expected to be stored and worked on each year. At the present stage of development the package will:—

1. Store all data over years and sites on all clones currently undergoing selection.
2. Produce field plans either in the form of randomised complete blocks, $\propto$ designs or sequential layouts.
3. Analyse data collected from these trials.
4. Update the data base.
5. Produce score books and plot labels.
6. Summarise the data.
7. Provide a selection aid for the breeder, using either independent culling levels for some or all characters, or a selection index.
8. Compute correlations and regressions.
9. Print graphs and histograms.

(J. Brown)

09010 *Study biology of potato cyst eelworm including host parasite relationship and the nature of resistance*

Hatching tests were conducted *in vitro* with root diffusates from *S. vernei* CPC 4078, cv. Pentland Crown and two resistant clones, 8917b(3) and 12380abc(2) with respective susceptibilities to *G. pallida* (Pa_2) of 10% and <1%. Undiluted diffusate was added to groups of 100 cysts each week and the number of juveniles hatched was counted. At the end of the experiment the number of viable eggs remaining was counted and the percentage hatch of juveniles was estimated. Throughout the experiment *S. vernei* and 12380abc(2) stimulated a significantly lower hatch of juveniles than did Pentland Crown.

A series of hatching tests conducted in pots in the glasshouse as previously described (SPBS Ann. Rep. 1979-80, p. 85) was completed in 1981. The clones studied were cv. Arran Banner, 9559ab(2), 8917b(3) and 12380abc(2). Bags of cysts were buried in the pots and were sampled at weekly intervals for 4 wk and then at week 6. Differences in numbers of residual eggs were apparent from the first week, with Arran Banner giving a significantly higher hatch than all the other clones except in week 3. Clone 12380abc(2), the most resistant hybrid, had a greater number of unhatched eggs on all sampling occasions.

The results suggest that hybrids of *S. vernei* x *S. tuberosum* inherit the reduced hatching activity of *S. vernei*, and that this contributes to overall resistance.

(J. M. S. Forrest, M. S. Phillips, Linda A. Farrer)

09011 *Assess potato breeding material for resistance to potato cyst eelworm. Improve screening techniques*

In 1981, 529 clones were screened in closed containers for resistance to *Globodera rostochiensis* (Ro_1) and 669 to *G. pallida* (Pa_2). Slightly more than half of these clones came from the commercial breeding programme, and of those specifically bred for resistance to *G. pallida*, 30% had a susceptibility of 10% or less. The remainder of the clones tested were from the strategic breeding programme and 5% of them had a susceptibility of 10% or less. The closed containers were identified by bar-coded labels. The codes, together with counts of developing females, were entered into small hand-held terminals, and the data subsequently transferred to a micro-computer for analysis. This procedure has led to substantial savings in time and effort.

The development of a pot test for screening bulks of seedlings (SPBS Ann. Rep. 1980-81, p. 101) was successfully concluded with a test of 100 progenies derived from *S. vernei*. There was a significant correlation between resistance as assessed by the seedling test and by closed container tests of tubers from the same progenies ($r=0.82$, $p<0.001$). The test is now used routinely for identifying progenies containing useful levels of

resistance to *G. pallida*, and for estimating the general and specific combining abilities of parents.

(J. M. S. Forrest, M. S. Phillips, Linda A. Farrer)

09012 *Assess potato breeding material for resistance to and infection with viruses X, Y and leafroll*

Major gene resistance

Seedlings of 79 progenies of crosses made for virus resistance were selected for resistance to potato virus Y (PVY) and potato virus X (PVX). From 9000 seedlings inoculated, 3300 resistant ones were kept for further assessment for other characters.

For both spray inoculation at the cotyledon stage and later hand inoculation to infect escapes, the standard practice at Pentlandfield is to inoculate seedlings separately with PVY one day and PVX the next, in case mixed inoculum would decrease the success rate of PVY inoculation. An experiment to test whether this is necessary for hand inoculation suggested that any difference in success rate between mixed and separate hand inoculation with concentrated inoculum is very small, but not necessarily too small to cause some escapes (*ca.* 1%) in the large batches of seedlings screened.

Two hundred and seventy clones were screened for resistance to various strains of PVY and PVX by sap or graft inoculation. The new cv. Kirsty showed major gene resistance to the common and B strains of PVX and the common and C strains of PVY. It may also be resistant to the A strain and to a VN strain of PVY. The new cv. Fiona also showed major gene resistance to these two strains of PVX and the common strain of PVY, and may also be resistant to the A, C and certain VN strains. The cultivar Baillie has major gene resistance to the common and B strains of PVX, and the common and C and a VN strain and possibly A strain of PVY; cv. Sheriff is resistant to all these PVY strains and the B strain of PVX.

Leafroll and PVY trial

Four hundred and thirty clones were exposed to potato leafroll virus (PLRV) and PVY in our trial at PBI, Cambridge in 1980, and evaluated in 1981. The incidence of infection with each virus was moderate: in plots of the resistant control cv. Pentland Crown 12.5% of the plants became infected with PVY and 28% with PLRV.

Most of the clones bred for virus resistance appeared as resistant as Pentland Crown to PVY and six of them were also more resistant to PLRV than Pentland Crown. Kirsty showed more resistance to PLRV than Pentland Crown, and as much resistance to PVY. Fiona also showed as much PVY resistance as Pentland Crown, but was susceptible to PLRV.

Three Neo-Tuberosum clones appeared more resistant to PLRV than Pentland Crown, and one of these also seemed resistant to PVY. Another ten were classed as resistant to PLRV as Pentland Crown. Nine clones of Group Phureja showed more resistance to PLRV than Pentland Crown and also good resistance to PVY. Several others appeared as resistant as Pentland Crown to PLRV, PVY or both.

(Ruth M. Solomon)

09013 *Assess potato breeding material for resistance to soil-borne viruses. Improve screening techniques*

Tobacco rattle virus

In a field trial for resistance to tobacco rattle virus (TRV) grown at Tayport, Fife in 1980, the new cultivars Kirsty, Fiona and Sheriff were identified as susceptible to spraing. In the 1981 trial cv. Provost was susceptible to spraing, and cv. Baillie was susceptible to internal rust spot, which may be due to TRV. Baillie has shown a limited susceptibility to TRV spraing in trials in four years, usually showing spraing in a few tubers.

Potato mop-top virus

A field trial for resistance to potato mop-top virus (PMTV) was grown at Braco, Perthshire in 1980. Samples of the harvested tubers were grown and the plants were scored for haulm symptoms in 1981, the rest having been scored for primary spraing symptoms in or on the tubers. Infection was extensive over the field and at high levels; the percentage of tubers showing spraing from 30 plots of the susceptible control cv. Arran Pilot ranged from 0 to 60%.

Of 46 unnamed clones, two were identified as resistant to both spraing and haulm symptoms, with no more than one tuber of plant affected out of four plots. Two clones appeared resistant to spraing but susceptible to haulm symptoms, and three were susceptible to spraing but showed no haulm symptoms. The other 39 clones showed at least some susceptiblity to both kinds of symptoms.

The resistant cv. Redskin showed little spraing and no haulm symptoms. The cultivars Stormont Enterprise, Pentland Lustre, Pentland Meteor and Croft also showed little spraing but did show haulm symptoms; cv. Pentland Crown was susceptible to spraing but showed no haulm symptoms. Kirsty proved moderately susceptible to spraing and haulm symptoms. Sheriff and Baillie proved susceptible, and Provost slightly susceptible, to both symptoms.

(Ruth M. Solomon)

09014 *Study the biology of common scab, gangrene, skin spot, dry rot, soft rot and powdery scab*

Soft rot

Routine assessment of the susceptibility of tubers to soft rot was begun, using the method developed with collaborators from Lanchester Polytechnic (Bourne, McCalmont and Wastie, 1981, Potato Research *24*, 409-415). A wide spread of susceptibility was apparent in the 26 clones examined, with two diploid clones appearing among the most resistant. A comparison of incubation temperatures (20 and 25°C) and isolates (kindly supplied by SCRI Mylnefield, and DAFS ASS, East Craigs) indicated that 15 cultivars ranked similarly when tested with one isolate at both temperatures. An isolate of *Erwinia carotovora* ssp. *carotovora* was generally more aggressive than three isolates of *E. carotovora* ssp. *atroseptica* when tested on four cultivars. Consistent differences have appeared between the rank order of 15 cultivars tested in 1981 and the rank orders derived from the 1979 and 1980 tests. For unknown reasons, cv. Stormont Enterprise was considerably less resistant in 1981 than hitherto.

Dry rot

Experience has shown that the 12 cultivars used as standards to represent a range of scores for resistance/susceptibility to *Fusarium solani* var. *coeruleum* do not react to *F. sulphureum* in the same way. Nevertheless, in 1981 three boxes of 20 tubers of the standard cultivars were inoculated with each pathogen and the extent of invasion subsequently scored on the standard nought to twenty four scale. The rank correlation coefficient between the order of resistance to each pathogen was 0.72 ($p<0.05$), with cv. Catriona being the most susceptible to both fungi.

Gangrene

Cornmeal-sand (CMS) and cornmeal-peat (CMP) cultures were further compared as sources of inoculum in the standard rolling test (see SPBS Ann. Rep. 1980-81, p.99). The mean disease score of three 20-tuber samples of each of 12 cultivars after 10 wk incubation at 4°C (standard eror of mean in parentheses) was 6.9 (0.61) and 1.3 (0.11) for CMS and CMP respectively. In a similar series inoculated after wounding the tubers with a nail-board, the mean disease scores were 10.8 (0.40) and 8.3 (0.42) respectively. The latter two means differ significantly, indicating that CMS is a more effective carrier for the pathogen even on wounded tubers.

(R. L. Wastie)

09015 *Assess potato breeding material for resistance to fungal diseases. Improve screening techniques*

Late blight

Glasshouse tests for foliage blight resistance were carried out on 908 clones from the commercial and strategic breeding programmes in 1981. Of fifth year selections from the commercial programme, 50% of 46 clones bred for blight resistance and 13% of 214 clones from other crosses showed good resistance, scoring 6 or more on the 1-9 scale of increasing resistance, as did 20% of 152 sixth year selections not bred for blight resistance.

A field trial to assess the foliage resistance of advanced commercial selections was carried out again at Yonderton Farm, Ayrshire. Of 35 early clones, seven stood out as more resistant than cv. Maris Peer, including the new cv. Baillie, and of 55 maincrop clones 22 were as resistant as cv. Record. The results for maincrop clones showed reasonable agreement with previous glasshouse test results ($r=0.84$, $p<0.05$).

Laboratory tests for resistance to tuber blight were carried out on fifth year and more advanced clones from the commercial breeding programme. Of 116 early clones tested, 34% were as resistant as the resistant Maris Peer; of 329 maincrop clones 24% were as resistant as the resistant cv. Stormont Enterprise. Eighteen % of 102 Neo-Tuberosum clones and 8% of 148 diploid clones also showed this level of resistance. A higher overall level of infection than in recent years was achieved in the maincrop trial by lifting the tubers 2 weeks earlier, in the third week in August, and lightly spraying with water before inoculation.

Further work on factors affecting the resistance tests was carried out by P. H. Flavelle, a sandwich student. A glasshouse test of six cultivars planted at four intervals of 1 week and inoculated 4 weeks after the last planting when the youngest plants were 20-30 cm high showed that there was little diffeence in susceptibility between plants inoculated 5, 6, or 7 weeks after planting but that the youngest plants were significantly more susceptible.

Gangrene

Clones from the strategic breeding programme formed a larger proportion than usual of the material assessed in the winter of 1980-81. Thirty three % of 243 Neo-Tuberosum clones obtained a score of 7 on the 1, 3, 5, 7, 9 scale of increasing resistance. Of 264 commercial breeding clones from the sixth year of selection onwards, 52% showed this level of resistance. Two hundred and fifty two of the clones had been previously tested in 1979-80, and 210 had received the same or adjacent rating in both years.

Common scab

Fifth year selections from the commercial breeding programme were assessed for resistance under polythene tunnels at the Murrays farm in 1980. The

overall level of scab was again low, and the tunnels have since been discontinued. The more advanced selections from the commercial breeding programme were assessed in a field trial in 1980 at Scoughall Farm near Whitekirk, East Lothian. Twenty six% of 152 clones tested fell into the two resistant categories of the five point scale. This level of resistance was also shown by 52 % of 161 Neo-Tuberosum clones and 56% of 172 diploid clones in a trial of strategic breeding selections at Archerfield, near Gullane, East Lothian.

(Helen E. Stewart, R. L. Wastie)

09016 *Manage the Commonwealth Potato Collection of Latin American origin. Liaise with the Dutch/German gene bank*

The Commonwealth Potato Collection, which contains both wild and cultivated species from the gene centre of the potato, Latin America, provides a worldwide service to potato breeders and research workers. It is maintained as true seed. During the year, 385 samples were despatched to Northern Ireland for eelworm resistance screeening and 74 others to Australia, Iraq and three United Kingdom centres, for breeding, physiological studies and tissue culture work.

(D. R. Glendinning)

09018 *Evaluate Neo-Tuberosum potatoes as parental material for use in breeding cultivars*

The Neo-Tuberosum potato population derives from South American primitive tetraploid cultivars of the Andigena type. Work commenced at the John Innes Institute *ca.* 1960 with the raising of seedlings from about 270 Andigenas from the Commonwealth Potato Collection, and the programme was transferred to the Scottish Plant Breeding Station in 1967. An initial objective was to demonstrate that Andigena, which is ill-adapted to our climate, being very late maturing and low yielding, very susceptible to blight and bearing numerous small and often ill-shaped tubers, could be improved by selection and thus could have been the origin of our 'Tuberosum' commercial potatoes. This objective was achieved and in 1969 the term 'Neo-Tuberosum' was adopted for this selected material. The current objective is the demonstration of the potential of the improved material for use in breeding cultivars. Tuberosum is believed to derive from only a few random samples of Andigena introduced casually from the sixteenth century onwards, and Neo-Tuberosum derives from a much larger and more representative sample and seems likely to contain new and useful genetic variation.

A system of recurrent mass selection in large populations was used to bring about steady improvements in the characters mentioned above whilst retaining wide variation in other respects, e.g. in skin and flesh colours, and

also, it was hoped, in other characters which could not be readily observed and selected such as disease resistances. Selected clones have been assessed agronomically, tested for disease resistances and culinary properties, and used as parents in controlled breeding. A few have been used experimentally in the commercial breeding programme, being crossed with Tuberosum and the resultant progenies selected alongside the normal material of that programme.

Recurrent mass selection was discontinued in 1978 and intensive evaluation of the potential of neo-Tuberosum commenced in 1979 with a pollination programme for assessment of Neo-Tuberosum parents in crosses with Tuberosum and with the multiplication of Neo-Tuberosum clones for yield trials. Replicated yield trials have been conducted, including 'earlies' trials, and incorporating two harvest dates in each trial. Neo-Tuberosum x Tuberosum selections from the commercial breeding programme have been included in these trials along with the Neo-Tuberosum clones. Disease resistance screenings, previously restricted, have been extended to general surveys, and culinary assessments have increased.

It has been shown that selections from Neo-Tuberosum and from Neo-Tuberosum x Tuberosum hybrids of 'early' and 'maincrop' maturities are capable of outyielding cultivar controls of comparable maturity. The controls included the cultivars Pentland Javelin, Wilja, Estima (earlies) and Pentland Crown, Pentland Ivory and Maris Piper (maincrops). Yields were assessed at two lifting dates and revealed that some clones combined early tubering and bulking with late foliage senescence and high final yield.

Surveys of disease reactions have shown about 60% of Neo-Tuberosum selections to be as resistant or more so than the best cultivar controls to common scab, about 35% to foliage blight, and about 45% to gangrene; in the 1981 tuber blight tests 17 were unblighted and a further 17 were very little affected among 102 tested. Many appear resistant to PVX, and field tests at Cambridge have revealed some apparent leafroll resisters and have confirmed indications from glasshouse tests that several are resistant to PVY; the glasshouse tests indicate that the latter are usually also resistant to virus A, virus C and veinal necrosis virus. About half those tested are resistant to wart, and in Israel a few have appeared resistant to *Verticillium*. A very few appear highly resistant to eelworm *Globodera pallida* (pathotype 'E') and *G. rostochiensis* (pathotype 'A') and it is a feature of the data that, with a few exceptions, reactions to pathotypes 'A' and 'E' tend to be similar in Neo-Tuberosum.

In a survey of over 300 clones basic flesh colours ranged from white (20%) through cream and lemon to yellow (5%), anthocyanin occurring in about 18%, usually in the vascular ring but occasionally colouring the whole flesh red or purple. Specific gravities ranged from 1.055 to 1.110 with about 18% under 1.070 and 8% over 1.090; the range for eleven cultivars was 1.070 to 1.098 with cv. Record having 1.086 and cv. Golden Wonder 1.098. 75% were as good as the cultivars for cooked tuber quality and when crisped 25%

were superior to all the cultivars which included the standard crisper, Record. Flavours are generally within the commercial range. Some clones tested under factory conditions by the Potato Processors' Association for suitability for crisping have performed exceptionally well, and in addition some have been crisped satisfactorily direct from low temperature storage. Wide ranges of protein and vitamin C contents have been detected with some clones having higher levels than were found in cultivars assessed with them.

(D. R. Glendinning)

09019 *Breed diploid potatoes and evaluate as potential parents for diploid and tetraploid cultivars*

This programme is based on primitive diploid South American material (Phuerja and Stenotomum types) from the Commonwealth Potato Collection. It was initiated at the John Innes Institute in the early 1960s and transferred to the Scottish Plant Breeding Station in 1967. Cultivated diploid types are less frequent in South America than tetraploid Andigena types and, perhaps for this reason, have not apparently contributed to the origin of Tuberosum although a few have been used in modern breeding. The initial population was subjected to recurrent mass selection to improve tuber size, shape and yield, and general adaptation. Progress was slower than in Andigena, probably because the diploids are strictly outbreeding while a substantial measure of inbreeding occurs in the tetraploids, and improvements were still being effected up to 1979 when mass selection was suspended to permit intensive evaluation of material in hand. Products of this programme have not yet been introduced to the commercial breeding programme but pilot-scale crossing with Tuberosum has been done within the diploid programme itself. Diploid hybrids were obtained by crossing the Tuberosum dihaploids (see Project 09020), and tetraploid hybrids by the direct crossing of Tuberosum tetraploids with diploids which, due to a meiotic abnormality, produce a proportion of unreduced male gametes. This occurs in about 11% of our diploids and breeding to introduce it to a wider range of diploids is in progress.

Evaluation trials in 1981 showed that the best diploid clones have marketable yields comparable to the controls, the cultivars Pentland Crown, Pentland Dell and Maris Piper. While tuber shapes are less regular and tuber numbers are higher than the controls, the best clones are approaching modern commercial standards.

Both diploid and tetraploid hybrids between improved diploids and Tuberosum yielded well. In trials lifted at maincrop maturities four of ten diploid hybrids did not differ significantly in yield from the top yielding control, cv. Desiree. Of 31 tetraploid hybrids nine significantly and a further 14 non-significantly outyielded Desiree while none gave significantly less than that control. In trials harvested 12 weeks after planting some hybrids

showed a capacity for early tubering comparable to the 'early' cultivar controls.

Surveys have indicated the presence of resistance to scab, foliage blight, tuber blight, gangrene, PVX and, in a field test at Cambridge, a number have appeared resistant to PLRV or to PVY and, in some instances, to both. Resistances to viruses A and C have also been detected. A few are wart resistant, and others appear highly resistant to eelworm pathotype E.

The range of flesh colours observed is much as in Neo-Tuberosum. Specific gravities are often high, while some clones have excellent cooking or crisping quality. High vitamin C contents have been detected. Of particular interest is the occurrence, in some diploids, of interesting 'nutty' flavours.

(C. P. Carroll, M. J. De,Maine)

09020 *Produce, breed and maintain a collection of dihaploid potatoes. Use dihaploids to enhance disease resistance*

Dihaploids of good commercial cultivars have been used as parents for diploid hybrids in Project 09019, but currently the emphasis is on producing and evaluating dihaploids from Tuberosum breeding lines having high levels of quantitative disease resistances, and on selecting clones from tetraploid progenies obtained by crossing such dihaploids with other Tuberosum tetraploids.

Further testing of tetraploid progeny clones from foliage blight resistant dihaploids confirmed a high frequency of transmission of resistance to blight, through some of the dihaploid parents. Disease reactions have been assessed on potted glasshouse plants and in field trials. Correlation coefficients for glasshouse tests in 1980 and 1981 and for 1981 glasshouse and field results were 0.85 and 0.77 respectively.

Detached leaflet tests of blight resistance in tetraploid seedling progenies of highly resistant dihaploids indicated differences in the effects of susceptible tetraploid parents. Progenies of cv. Pentland Crown, for example, generally had lower mean values. The results indicated also that tetraploids obtained by colchicine induced chromosome doubling were not as effective in transmitting foliage blight resistance to their progeny as were the resistant dihaploids from which they were obtained.

Dihaploids generally are lacking in vigour, some cannot be grown successfully out of doors and tuber yields are usually low. On the other hand, tuber yields of tetraploid progenies of dihaploids ranged from 54 to 161% of Pentland Crown and mean tuber weights ranged from 81 to 342 gm.

The results suggest that in 4x progenies from dihaploid x 4x crosses, the level of disease resistance of the dihaploid parent may be a good guide to the resistance of the progeny whereas yield of the dihaploid is a poor guide to the yield of its progeny.

(C. P. Carroll, M. J. De,Maine)

09028 *Study mechanisms of genetic variability in* Phytophthora infestans *and the evolution of new pathogenic types*

Samples of blight received during 1981 — a 'blight' year — yielded races of *Phytophthora infestans* of greater complexity than those recorded during the past few seasons. This change was not attributed to any recent increase in acreage of cultivars with complementary R genes as was the case in the late 1960s when blight became epidemic on the $R_1R_2R_3$ cv. Pentland Dell. However, it is perhaps relevant that in recent years there has been considerable change in the pattern of cultivars grown; increased production of cultivars such as Maris Piper and Desiree, has provided for *P. infestans* a selection substrate differing genetically from that prevailing hitherto.

The spectrum of races present in the material from the east of Scotland differed substantially from that obtained from the west. The samples from the east contained a high proportion of races which were basically race 1,3,4. It is of interest that the majority of these races gave a positive reaction on leaves of the R_1R_3 and the $R_1R_3R_4$ standard differential hosts but they were negative on those of the R_1R_4 and the R_3R_4 hosts. This indicates the presence of a previously undetected gene or genes for resistance in the R_1R_4 and the R_3R_4 clones.

The samples from the west contained isolates of *P. infestans* which were susceptible to metalaxyl and some which were resistant to it. It was noted that the reaction to metalaxyl did not reflect any race pattern in the fungus.

(Jean F. Malcolmson)

09029 *Study mechanisms of quantitative resistance to potato late blight and identify resistant parental material*

A knowledge of a host's morphology and histology is basic to an understanding of a pathogen's reaction with it. There are considerable deficiencies in information of this nature in the potato; therefore, relevant details from tubers and leaves were recorded as part of a study of *Phytophthora infestans* on potatoes, using scanning electron microscopy.

In the eyes of tubers it has been discovered that the 'eyebrow' is a tangentially expanded compound leaf in which the rachis forms the eyebrow ridge. The structure usually designated the scale leaf is its terminal leaflet. This leaflet is a highly complex structure with a midrib and lateral veins and it bears both covering and glandular hairs and stomata. The stomata occurring on the margin are associated with vein endings and their pores are frequently filled with material, suggesting that they have a secretory function as hydathodes.

The eyebrow frequently bears two, and occasionally bears four, lateral leaflets which readily absciss so that often the only indication of their existence is a leaf scar which resembles a lenticel. Covering hairs and stomata have been observed on the eyebrow.

In section, the leaflets show a well developed vascular system with spiral thickening of the xylem. Unlike aerial leaves there is no differentiation of the lamina into palisade and mesophyll tissue.

With growth of the tuber, the eyebrow and its axillary tissue expands so that its subtending bud emerges. On emergence the scale leaves of the bud are well formed structures with stomata and frequently glandular hairs arranged along the adaxial midrib. There is evidence that here too, some of the stomata have a secretory function.

Observations in the region of the apical buds of tubers have shown that lenticel formation follows the spiral phyllotaxy of the plant. The filling cells of lenticels develop in radial columns and do not appear to be loosely arranged until proliferation occurs. Lenticels occur most frequently in association with stomata but occasionally they have been observed in their absence. Proliferation of lenticels is the result of increased cell number whereas tissue proliferation in leaves, which occurs under certain environmental conditions, results from the enlargement of mesophyll cells.

The occurrence has been noted of pores which are scattered over the tuber surface and which penetrate the periderm. The cells lining these pores appear to be arranged in an organised fashion but there is no development of filling cells, as in lenticels, so that the pores are not raised on the tuber surface.

Examination of leaves revealed the presence of stomata on the adaxial margin, scattered abundantly on the abaxial surface but rarely on the adaxial surface. The marginal stomata were associated with the tissue at the ends of veins and their pores were filled with contents suggesting, as in similar stomata on scale leaves of tubers, that they had a secretory function.

At the adaxial, proximal end of the leaf the midrib forms a well raised ridge and is a distinct structure whereas distally it forms a groove and its tissues are not distinct from those of the lamina. Where the midrib was raised, there were abundant stomata along the sides of the rib in the furrows which it formed with the lamina, but not on the apex of the ridge.

Both covering and glandular hairs have been observed on leaves. The glandular hairs had heads of either one or four cells. The former occurred mainly along the veins on the adaxial surface whereas the latter were predominantly distributed at random on the abaxial surface.

These studies have revealed a number of features which could have considerable significance in many host/pathgen interactions. Investigation of their role in relation to *P. infestans* is underway on a series of clones known to exhibit a range of reactions to blight.

The Cambridge S180 Scanning Electron Microscope at the MRC Clinical and Population Cytogenetics Unit, Edinburgh was generously made available for this work.

(Jean F. Malcolmson)

cv. PROVOST

National List and Plant Varieties Rights — 1981.

Maturity class:	First early.
Foliage:	Medium height, semi-erect-spreading.
Tubers:	Round to short-oval. Numerous. Uniform in shape and size. Skin white, flesh white, eyes shallow.
Cooking quality:	Flesh firm; no disintegration; white to pale cream, no after-cooking blackening; flavour mild.
Processing quality at mature lift:	Specific gravity higher than cv. Home Guard. Crisp colour very good; superior to Home Guard.
Yield potential:	Has consistently equalled or outyielded (though rarely significantly so) controls in trials at numerous centres over 8-9 years.

* Disease resistances:

Wart	Immune
Blight — foliage	1
— tubers	6
Common scab	7
Gangrene	1
Skin spot	5
Dry rot	5
Potato cyst nematode	Susceptible
Virus X	Susceptible
B	,,
Y	8
A	9
C	9
Leafroll	No data

* Numerical values on 1-9 scale where 9=maximum resistance or hypersensitivity.

Summary: An early bulking, high yielding early cultivar. Tubers of good size and shape; good quality for fresh use and for crisping.

cv. BAILLIE

National List and Plant Varieties Rights — 1981.

Maturity class:	Second early.
Foliage:	Semi-erect, spreading bushy habit. Good ground cover.
Tubers:	Round-oval, bold, uniform size and shape. White skin, cream flesh.

Cooking quality: Consistently good quality for fresh use. No after-cooking blackening.

Processing quality: High dry matter when mature. Has given good results in laboratory and commercial crisping tests.

Yield potential: Consistently high yields over different sites and years, including trials in Spain.

*Disease resistances

Wart	Immune
Blight — foliage	3
— tubers	5
Common scab	5
Gangrene	7
Skin spot	7
Potato cyst nematode	Susceptible
Virus X	9
B	9
Y	9
A	Susceptible
C	9
Leafroll	4
TRV	Susceptible

*Numerical values on 1-9 scale when 9=maximum resistance or hypersensitivity.

Summary: A high yielding cultivar producing tubers of attractive uniform shape of good table and crisping quality.

cv. SHERIFF

National List and Plant Varieties Rights — 1981.

Maturity class: Early maincrop.

Foliage: Medium height, vigorous, spreading.

Tubers: Round-oval, uniform, numerous. Shallow eyes, white skin and pale cream flesh.

Cooking quality: High dry matter, therefore mealy texture with some distintegration. Occasional after-cooking blackening.

Process quality — crisping:
Low oil absorption and good crisp colour. Consistently higher quality than cv. Record in laboratory and commercial assessments.

Yield potential: Has always equalled or exceeded Record in tuber yield.

* Disease resistances

Wart	Immune
Blight — foliage	7
— tubers	8
Common scab	7
Gangrene	5
Skin spot	5
Dry rot	5
Potato cyst nematode	Susceptible
Virus X	Susceptible
B	9
Y	9
A	9
C	Susceptible
Leafroll	8

* Numerical values on 1-9 scale when 9=maximum resistance or hypersensitivity.

Summary: Distinguished by high expressions of yield, quality and disease resistances. The variety is an all-round improvement on cv. Record, for which it is intended as a replacement. Like Record it has a tendency to growth cracks in the tubers under certain undefined circumstances. The significance of this important defect in relation to all its advantages remains to be assessed in agricultural practice.

CYTOLOGY

The post of cytologist remained vacant during the year, and the ASO in the Cytology Unit left in September 1981. Work was restricted, therefore, to those routine screening tests essential to the continuance of breeding projects in the various crops. A substantial part of this work was in support of two potato schemes: the first of these was the transfer of improved germ-plasm from *S tuberosum* Group Phureja to the tetraploid level, which required determination of ploidy by root-tip counts, detection of aneuploid hybrids, and estimations of pollen stainability and diameter. The second was the production of Group Tuberosum dihaploids and their colchicine-doubled derivatives for disease resistance breeding and inheritance studies. This also required determinations of ploidy and detection of aneuploids, but in colchicined material the chromosomal make up of each generative layer (L_1, L_2, L_3) has also to be examined. For potato work in total some 300 root-tip chromosome counts, 70 epidermal chloroplast counts and 160 pollen diameter distributions were undertaken. In addition pollen stainabilities were provided for 110 clones.

Data on ploidy were obtained for the *Brassica* breeders in the swede and rape forms of *B. napus*. A search for haploids was undertaken among 44 plants raised from undersize seeds of swedes but none was found. A number of ploidy determinations were made in rape plantlets derived from tissue-culture (leaf explants): allotetraploids and octoploids were found.

In barley, a check was made on seedlings in the programme for the production of haploids by the *Hordeum bulbosum* chromosome elimination method, which was found to be operating successfully. The programme for the use of irradiated pollen requred cytological checks on chromosome complements and karyototypes in the resulting seedlings: most were without abnormalities. In all about 150 barley chromosome counts were undertaken.

(C. P. Carroll)

LIBRARY

The Library provides an information and general library service to research staff of the Institute as well as to outside enquirers. Over 170 periodicals are currently received and the book stock numbers around 1,200 items. In

addition, there are collections of reports, technical information and reprints.

During 1981, a total of 698 volumes were borrowed from the Library, an increase of over 20% on 1980 figures, while inter-library loans accounted for another 366 items. Thirty six specific enquiries were handled and 34 bibliographies were compiled on subjects ranging from the use of biometrical analysis in cross prediction, to methods of analysing the different barley quality factors. Eighty one acquisitions were added to the book stock and four new journal subscriptions were taken out.

During the year, the procedure for producing the regular current awareness bulletin was computerised using a program provided by the ERCC. As well as simplifying the clerical effort involved in the production of the bulletin, advantages of the new system include the greatly increased facility for providing individual SDI services, and the facility for free-text searching the data base of back numbers.

The librarian undertook seven French and German translations in 1981. Three meetings were attended, including a meeting of the Scottish Agricultural Libraries Group.

(Barbara E. Asher)

PHOTOGRAPHY/ILLUSTRATION

A large proportion of the year' work was taken up with the preparation of demonstrations for three major events. These were the International Barley Genetics Symposium, which required a set of posters and material for publication and lectures, the Ayr Flower Show and the Scottish Agricultural Winter Fair, at both of which displays on potato breeding were shown. The displays were well received and much of their success was attributed to the use of the Airbrush technique.

Additions to the photographic equipment were the Horseman 5 x 4 in. format monorail camera and a Bowens Quad 2002 electronic flash pack and head. These are used mainly for studio based work or when a high standard of photography is required. The substitution of the Nikon 35 mm system for the Pentax system permitted a marked improvement in the quality of reproduction, especially for macro-photography.

A slide filing system was introduced to the Apple microcomputer with an option of using disks or card filing systems. This permits staff to obtain information on any of the 2500 slides held in the library.

(Geraldine Cruicksha·

STATISTICS AND COMPUTING

This was the first full year in which the microcomputer based data captu and processing system was in operatin involving four M50f hand-helo terminals, five Mettle PK electronic balances and six Apple II microcomputers. The system allows data to be transfered directly from the hand-held

terminals and balances to the microcomputers. Analyses can then be carried out on the microcomputers or the data can be transferred to an ERCC mainframe computer for processing. The microcomputers have been sited at strategic points throughout Pentlandfield and one is located at the Murrays farm thus ensuring easy access for all staff. A central feature of the system is the communications package, X-TALK, written at ERCC, which allows the Apple microcomputers to serve as interactive terminals to the ERCC mainframe and allows files to be passed between the microcomputers and the mainframes.

The system has already been widely used, speeding up many routine data processing tasks and introducing several more staff to computing technology. The hand-held terminals have proved to be very helpful for laboratory and indoor work generally. The number of hand-written records and the time to prepare data for the computer have been reduced substantially. The most common use has been in routine screening programmes, particularly in potato breeding. The potato cyst nematode screening application involves reading bar code labels directly into the terminals via a wand scanner. For field trial scoring the terminals have been only partially successful; the display can be difficult to read in strong sunlight and this has limited their use outdoors.

The use of the electronic balances together with an Apple microcomputer for routine weighing has also been successful. Not only is the complete weighing process itself speeded up but, on completion, the data are correctly coded, sorted and written to disk ready for analysis. In addition a neat computer listing of the data is available. When not being used for data capture the Apple microcomputers are available for uses such as word processing, the statistical design and analysis of routine trials, key to disk data entry, label printing and general data processing. Much of the work previously done on the Wang 2200 has been diverted to the Apples and the card punch has also been used much less.

Although some work has been diverted from the ERCC mainframe to the microcomputers the use of the mainframes continued to increase. The number of jobs run on ERCC mainframe during 1981 was 5058, an increase of 17% over the previous year. These figures reflect the wider range of facilities at ERCC and the easier access to them.

The statistical consultancy service continued as before. Genstat and CVT remained the two most popular statistical packages, though some work previously done using CVT was transferred to the microcomputers using the Variety Trial Library which was written especially for them.

(J. W. McNicol, R. Kidger, S. Ng[1])

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[1] Department of Mathematics and Statistics, Sheffield City Polytechnic.

SCOTTISH HORTICULTURAL RESEARCH INSTITUTE ASSOCIATION

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The 1981 AGM was held on 19 February. Following the business of the meeting the Director presented a paper on the plans and programme for the future of the Scottish Crop Research Institute.

During the year several meetings were held between the Committees of the Association and the Scottish Society for Research in Plant Breeding to discuss the creation of the Scottish Society for Crop Research as an organisation to represent their respective interests.

Well supported field demonstrations of research concerning soft fruits were held for members in the summer, with a 'Strawberry Walk' on the evening of 9 July and with a 'Fruit Walk' dealing predominantly with raspberries on the afternoon of 25 July.

A winter meeting 'Producing quality seed potatoes in Scotland' was held on 26 November.

Publications

During the year the following were financed by the Association:—

Bulletin No. 18 (March 1981)

Brassica improvement and research at SCRI *by* T. Hodgkin and A. B. Wills, SCRI, pp.1 - 4.

Hybrid brassicas and the sib story *by* A. B. Wills, SCRI, pp. 5 - 8

Cabbages for courses *by* M. J. Day, NIAB, pp. 9 - 18.

Raising Brussels sprouts and cabbage plants *by* P. B. Tatham, ADAS, pp. 19-24.

Bulletin No. 19 (June 1981)

Progress with the Littau raspberry harvester *by* P. Waister and M. R. Cormack, SCRI, pp. 1 - 7.

The effects of raspberry cane disease on yield *by* B. Williamson, SCRI, pp. 8 - 14.

Recent research on virus diseases of red raspberry — the viruses, their effects and control *by* A. T. Jones, SCRI, pp. 15 – 25.

Blackberries and hybridberries for Scotland *by* M. R. Cormack, SCRI, pp. 26 – 30.

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Dr Ralph Riley, Secretary of the Agricultural Reasearch Council, presented the Eleventh SSRPB lecture entitled 'Research: an agricultural resource' at the Kellogg Hall, Bush Estate, on 23rd April.

The society held its 60th Annual General Meeting at Pentlandfield on 23rd July when the work of SPBS up to date of amalgamation with the

Institute, 1st February, 1981, was reviewed by Dr John Holden. Following the AGM there was an extraordinary general meeting of the Society at which it was agreed to change the name to the Scottish Society for Crop Research (SSCR) and to admit as members all members of the SHRI Association, together with the adoption of some changes in rules under the Friendly Societies Act. Immediately following this AGM the Inaugural General Meeting of the SSCR was held when Mr James Gray, OBE, TD, was appointed Chairman and Mr W. Andrew Biggar, CBE, MC, BSc, FRAgS, was appointed Vice Chairman. Fifteen other members were also appointed to serve on the Committee of Management of the Society for the year 1981/82.

It is estimated that the enlarged Society will have a membership of approximately 500.

Mylnefield

The year began with milder and drier weather than average but a dull and wet March followed by a bright April ensured favourable planting and growing conditions in the early part of the season. A dry spell from July to August caused drought symptoms in some crops and brought on early senescence in some maincrop potatoes.

Wind

Windspeeds in January and February were 27% above the long term average but thereafter average windspeeds were close to or slightly below average.

Temperature

After a mild winter, temperatures from April to September were generally near average. October and December were each the coldest for those months since our records began in 1954 and the lowest air minimum in December (-11.2°C) was the lowest December temperature recorded. The warmest weather of the year was during the last week in August when air temperature reached 24.8°C on one day and the average maximum temperature for the week was 21.8°C.

Rainfall

A dry summer was followed by the wettest September since our records began, rainfall being nearly three times the average for that month. March, too, had been wet with more than twice the average rainfall.

Sunshine and Solar Radiation

June and July were duller than average with only 83% of the 25 year mean of sunshine hours. Solar radiation over the same period was close to the 12 year mean (radiation measurements were not begun until 1968).

MYLNEFIELD 1981

Month	Temperature: Daily Air Maxima Mean °C	Daily Air Maxima DFA ★	Daily Air Minima Mean °C	Daily Air Minima DFA ★	0·1m Soil Mean °C	0·1m Soil DFA ★	0·3m Earth Mean °C	0·3m Earth DFA ★	Accumulated Day Degrees Above 6°C	Accumulated Day Degrees Below 6°C	Days Ground Frost	Potential Evap-oration mm	Rainfall Total mm	Rainfall DFA ★	Bright Sunshine hours Total	Bright Sunshine hours DFA ★	Mean Daily* Solar Radiation mWh/cm²	Windspeed Mean km/h	Windspeed DFA †
January	6·1	+0·5	2·8	+2·8	2·0	+0·5	3·3	+0·8	15	95	26	2·8	33·9	−29.3	60·1	+6·9	52	14·5	+3·4
February	6·0	+0·3	0·7	+0·6	2·1	+0·5	3·5	+0·9	12	85	21	13·5	44·5	−4.0	78·5	+4·5	115	14·9	+2·8
March	9·0	+1·0	2·7	+1·0	4·3	+1·0	5·2	+1·0	43	44	15	29·7	96·1	+51·9	89·2	−16.6	202	13·0	−1.7
April	11·1	0·0	3·3	+0·1	7·1	+0·9	8·1	+1·2	68	30	19	60·7	23·9	−17.4	177·2	+18.2	395	10·7	−3.9
May	14·5	+0·8	7·0	+1·2	11·3	+1·2	11·0	+0·9	146	9	4	78·4	54·8	−1.3	174·8	−9.0	453	12·1	−0.5
June	15·9	−1.1	9·0	−0.4	13·8	−0.1	13.6	+0.1	202	1	1	87·3	49·1	+0·2	148·6	−34.8	516	12·3	+0·4
July	18·3	−0.1	10·3	+0·2	14·9	−0.3	14·5	−0.6	255	1	0	84·1	44·2	−20.5	148·8	−27.0	424	11·2	+0·5
August	19·6	+1·5	11·0	+1·0	15·8	+1·5	15·1	+0·3	286	0	0	77·7	15·8	−53.8	173·0	+18.3	398	9·1	−0.7
September	16·9	−1.0	9·7	+1·2	12·7	+1·2	13·4	+0·8	220	0	0	46·4	160·4	+101·7	118·2	−1.1	261	12·5	−1.7
October	9·8	−2.9	2·6	−3.7	5·1	−3.2	7·7	−2.1	46	37	21	21·4	63·6	+6·1	119·3	+28.3	155	11·0	−0.3
November	8·9	+0·6	2·8	+0.7	4·5	+0.5	6·2	+0·5	43	47	19	10·0	54·2	−2.0	66·5	−0.8	67	14·0	+1.9
December	2·8	−3.5	−3.2	−4.1	−0·3	−2.6	1·7	−1·8	2	194	28	0·0	55·2	−13.1	44·9	−0.1	38	9·2	−2.8

★DFA Deviation from Average 1954-1978

†DFA=Deviation from Average 1969-1978

Month	Mean Air temperature °C		Mean Soil temperature °C		Number of Days air temperature ≤ 0°C		Total rainfall	Number of wet days
	Max.	Min.	5 cm	10 cm	Air	Grass	mm	> 1.0mm
January	6·9	0·6	2·1	2·5	14	19	19·4	9
February	5·4	0·1	1·3	1·8	18	16	32·2	5
March	9·1	2·5	4·6	4·2	5	10	59·6	16
April	10·9	2·5	7·4	6·7	6	16	13·2	6
May	14·6	5·4	11·4	10·3	3	6	38·8	11
June	15·3	8·2	14·0	13·1	0	1	52·9	11
July	17·6	9·8	14·7	15·7	0	0	50·2	8
August	19·0	10·5	16·3	15·3	0	0	12·3	6
September	16·8	9·1	12·9	12·0	0	0	82·1	15
October	9·3	2·8	4·6	5·1	3	14	125·5	15
November	9·3	3.4	4.3	4·8	3	12	62·6	17
December	1·9	−4.3	−1.1	—★	23	28	43·2	8
Annual total	—	—	—	—	75	122	592·0	127
Annual mean (365 Days)	11·4	4·3	7·8	8·0★	—	—	—	—

★ The thermometer broke at the beginning of December and replacement was impossible until a partial thaw at the end of the month. The mean applies to 11 months (334 days) only.

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INSTITUTES FOR AGRICULTURAL RESEARCH IN GREAT BRITAIN

The research programmes of all the institutes supported from public funds are co-ordinated by the Agricultural Research Council. Most publish a report annually and details are obtainable from the Secretary of the Institute concerned.

ARC Institutes

Animal Breeding Research Organisation	King's Buildings, West Mains Road, Edinburgh, EH9 3JQ
Food Research Institute	Colney Lane, Norwich, NR4 7UA
Institute of Animal Physiology	Babraham, Cambridge, CB2 4AT
Institute for Research on Animal Diseases	Compton, Newbury, Berks, RG16 0NN
Letcombe Laboratory	Wantage, Berks, OX12 9JT
Meat Research Institute	Langford, Bristol, BS18 7DY
Poultry Research Centre	Roslin, Midlothian. EH25 9PS
Weed Research Organisation	Begbroke Hill, Yarnton, Oxford, OX5 1PF

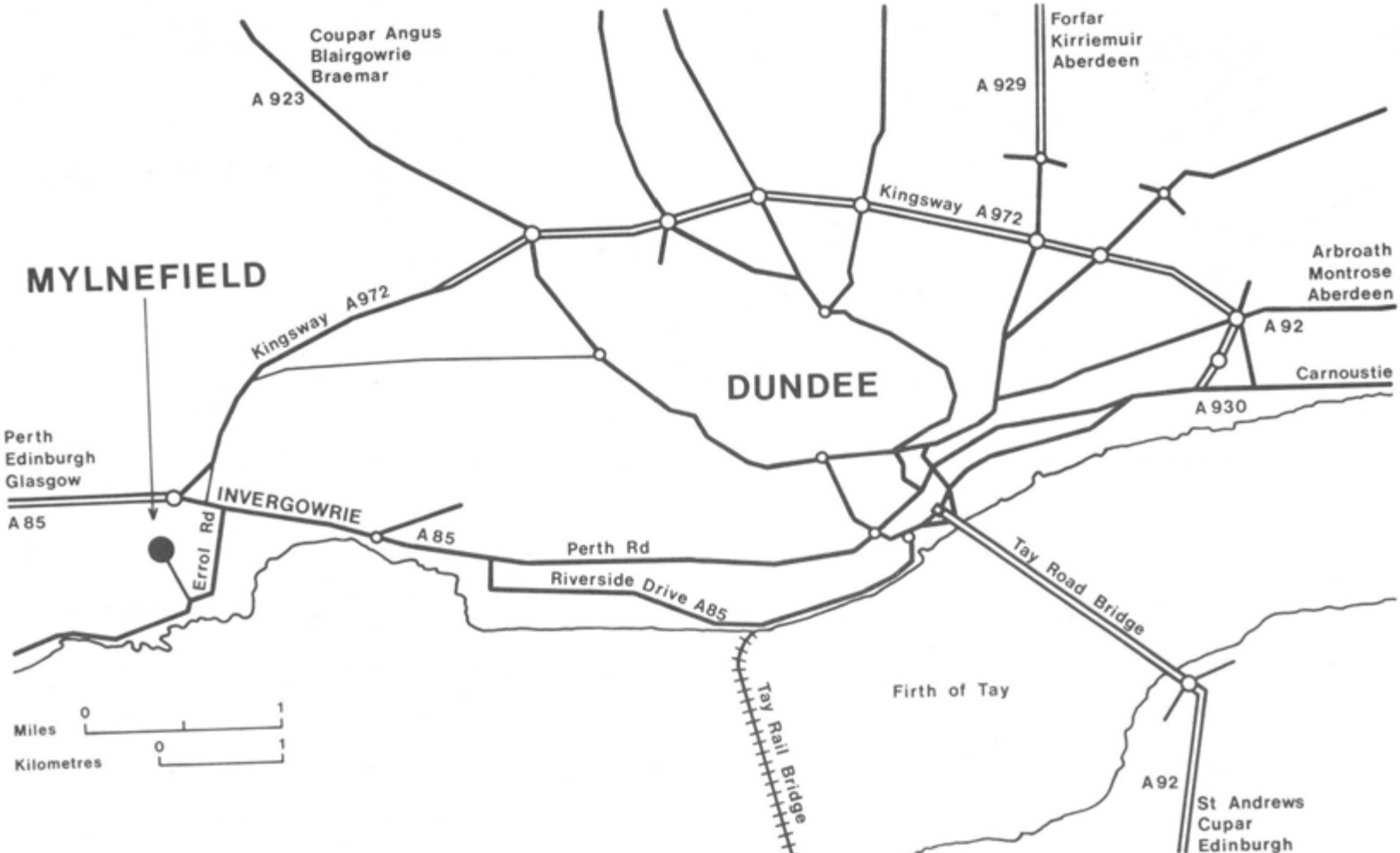
State-aided Institutes in England and Wales

Animal Virus Research Institute	Pirbright, Woking, Surrey, GU24 0NF
East Malling Research Station	East Malling, Maidstone, Kent, ME19 6BJ
Glasshouse Crops Research Institute	Rustington, Littlehampton, Sussex, BN16 3PU
Grassland Research Institute	Hurley, Maidenhead, Berks. SL6 5LR
Houghton Poultry Research Station	Houghton, Huntingdon, PE17 2DA
John Innes Institute	Colney Lane, Norwich, NR4 7UH
Long Ashton Research Station	Long Ashton, Bristol, BS18 9AF
National Institute of Agricultural Engineering	Wrest Park, Silsoe, Bedford, MK45 4HS
National Institute for Research in Dairying	Shinfield, Reading, RG2 9AT
National Vegetable Research Station	Wellesbourne, Warwick CV35 9EF
Plant Breeding Institute	Maris Lane, Trumpington, Cambridge, CB2 2LQ
Rothamsted Experimental Station	Harpenden, Herts. AL5 2JQ
Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth. Dyfed, SY23 3EB
Wye College, Department of Hop Research	Ashford, Kent, TN25 5AH

State-aided Institutes in Scotland

Hannah Research Institute	Ayr, Scotland, KA6 5HL
Hill Farming Research Organisation	Bush Estate, Penicuik, Midlothian, EH26 0PY
Macaulay Institute for Soil Research	Craigiebuckler, Aberdeen, AB9 2QJ
Moredun Institute (ADRA)	408 Gilmerton Road, Edinburgh, EH17 7JH
Rowett Research Institute	Bucksburn, Aberdeen, AB2 9SB
Scottish Crop Research Institute	Invergowrie, Dundee, DD2 5DA
	Pentlandfield, Roslin, Midlothian, EH25 9RF
Scottish Institute of Agricultural Engineering	Bush Estate, Penicuik, Midlothian, EH26 0PH

AAB	Association of Applied Biologists
ADAS	Agricultural Development and Advisory Service
ARC	Agricultural Research Council
ATB	Agricultural Training Board
ARS	Agricultural Research Service
BA	British Association
BAPB	British Association of Plant Breeders
BBC	British Broadcasting Corporation
CASE	Co-operative Awards in Science and Engineering
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CVT	Co-ordinated Variety Trials
DAFS	Department of Agriculture and Fisheries for Scotland
DANI	Department of Agriculture for Northern Ireland
DOMD	Digestible Organic Matter in the Dry Weight
DSIR	Department of Scientific and Industrial Research
EAPR	European Association for Potato Research
EEC	European Economic Community
EHF	Experimental Husbandry Farm
EHS	Experimental Horticultural Station
ELISA	Enzyme-linked Immunosorbent Assay
EM	Electron microscope
EMAS	Edinburgh Multiple Access (Computer) System
EMRS	East Malling Research Station
ERCC	Edinburgh Regional Computing Centre
ESCA	East of Scotland College of Agriculture
FAO	Food and Agriculture Organisation
FBPP	Federation of British Plant Pathologists
FRI	Food Research Institute
HEA	Horticultural Education Association
JMT	Joint Main Trial
NATO	North Atlantic Treaty Organisation
NFT	National Fruit Trials
NIAB	National Institute of Agricultural Botany
NLT	National List Trials
NSDO	National Seed Development Organisation
NVRS	National Vegetable Research Station
PBI	Plant Breeding Institute
PCN	Potato Cyst Nematode
PMB	Potato Marketing Board
RCCA	Research Council Co-operative Award
SAC	Scottish Agricultural Colleges
SARI	Scottish Agricultural Research Institutes
SERC	Science and Engineering Research Council
SDI	Selective Dissemination of Information.
SHRI	Scottish Horticultural Research Institute
SIAE	Scottish Institute of Agricultural Engineering
SMCO	S-Methyl Cysteine Sulphoxide
SNSA	Scottish Nuclear Stock Association
SPBS	Scottish Plant Breeding Association
SRC	Science Research Council
SSRPB	Scottish Society for Research in Plant Breeding
TGA	Total Glycoalkaloid
UK	United Kingdom
USA	United States of America
USSR	Union of Soviet Socialist Republics
VTSC	Virus tested stem cutting
WPBS	Welsh Plant Breeding Station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Carnoustie
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Perth
Edinburgh
Glasgow
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Perth Rd
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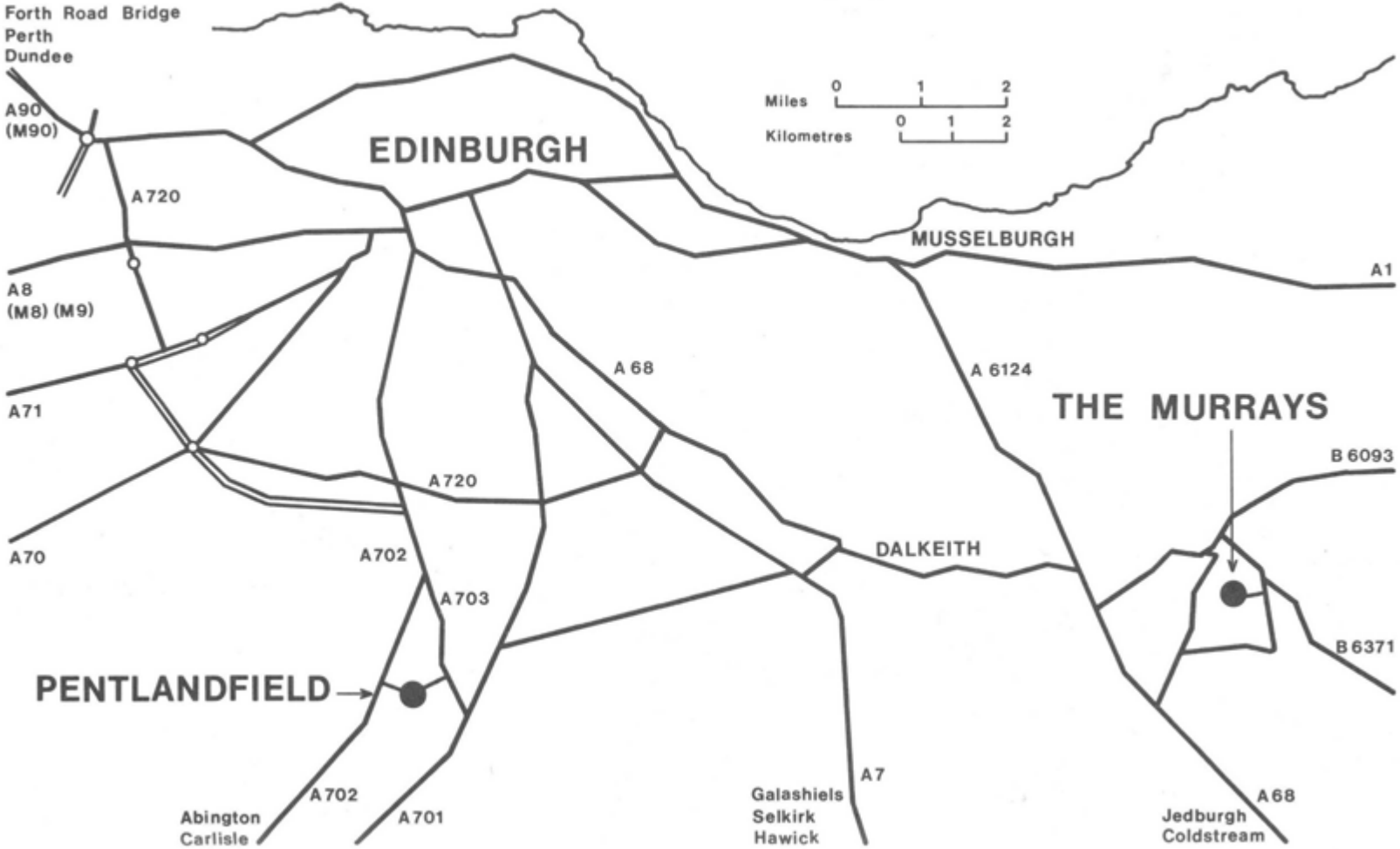
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